AFOSR PAMPHLET 64-1
1 October 1996

RESEARCH INTERESTS
and
BROAD AGENCY ANNOUNCEMENT
97-1
of the
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

BOLLING AIR FORCE BASE DC 20332-8080

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DEPARTMENT OF THE AIR FORCE
Air Force Office of Scientific Research (AFMC)
110 Duncan Avenue, Room B115
Bolling Air Force Base, DC 20332-8080

AFOSR 64-1

1 October 1996

RESEARCH INTERESTS OF THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

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Supersedes AFOSR Pamphlet 64-1, October 95.
No. of Printed Pages: 64
OPR: PKC Charity E. Conrad
Approved by: Dr. Joseph F. Janni, Director
Distribution: F

FOREWORD

The Air Force Office of Scientific Research (AFOSR) directs the entire basic research program of the Air Force. AFOSR's technical experts foster the transfer of research results accomplished under AFOSR sponsorship in Air Force laboratories, academic institutions, U.S. industry, and other Government agencies. Using a carefully balanced research portfolio, these research managers create new technology and advance current knowledge, enabling users in the Air Force and U.S. industry to produce world-class, militarily significant, and commercially valuable products.

In fiscal year 1995, AFOSR funded approximately 1,600 grants and contracts, totaling $239.9 million, to about 400 academic institutions and industrial firms. These included grants to university scientists, support for academic institutions, contracts for industry research, cooperative agreements, and support for basic research in Air Force laboratories.

AFOSR encourages the sharing and transfer of technology. Therefore, AFOSR welcomes proposals that envision cooperation among two or more partners from academia, industry, and Air Force organizations. Non-industry proposers should spell out in their proposals their interactions with industry and Air Force organizations, including specific points of contact. AFOSR also encourages proposers to cooperate with or use Air Force facilities; proposers should contact appropriate directorates in Air Force laboratories for this purpose. The *Directory* included in this pamphlet provides some initial contact points.

This pamphlet will guide proposers through AFOSR's research program and facilitate their preparation of research proposals. The pamphlet is divided into five sections:

The *Introduction* describes the Broad Agency Announcement (BAA), which is the mechanism used by AFOSR to solicit research proposals. It also provides an overview of the general approach used to submit proposals.

The *New World Vistas* section describes science and technology needed to support six future Air Force capability areas: Global Awareness, Dynamic Planning and Execution Control, Global Mobility in War and Peace, Projection of Lethal and Sublethal Power, Space Operations, and People.

The *Research Interests* section describes the basic research that AFOSR is interested in sponsoring.

The *Researcher Assistance Programs* section discusses associateship, faculty, and graduate school research programs. Most of these programs are designed to foster the mutual research interests of the Air Force laboratories and institutions of higher education.

The *Proposal Guidance* section is to be used in conjunction with the *AFOSR Proposer's Guide* (AFOSR Pamphlet 64-11) for submitting a proposal in response to this announcement.

The *Directory* lists the names, telephone numbers, mailing addresses, and e-mail addresses of AFOSR scientific directors and program managers, and the names, telephone numbers, and mailing addresses of Air Force chief scientists and laboratory task managers.

Anyone qualified to perform research is encouraged to contact AFOSR in accordance with the appropriate BAA and the guidelines given in this pamphlet. We particularly encourage proposals from historically black colleges and universities, minority institutions, and minority researchers.

Joseph F Janni

JOSEPH F. JANNI
DIRECTOR

I

Introduction

The Air Force Office of Scientific Research (AFOSR) manages all basic research conducted by the U.S. Air Force under this Broad Agency Announcement (BAA). To accomplish this task, AFOSR solicits proposals for research through a general BAA and specialized BAAs. Availability of all BAAs is published in the *Commerce Business Daily* (*CBD*). *

The general BAA outlines the Air Force Defense Research Sciences Program and is reprinted in Section IV, *Proposal Guidance*, for your convenience. AFOSR invites proposals for basic research in many broad areas. Section III of this pamphlet describes those areas in greater detail.

Specialized BAAs outline specific programs in which the Air Force has a high interest. Examples of specialized BAAs include the University Research Initiative and Historically Black Colleges and Universities (HBCU) programs. HBCUs are those institutions determined by the Secretary of Education to meet the requirements of 34 Code of Federal Regulations Section 608.2, and minority institutions are those certified by the Department of Education, Office of Civil Rights, to meet the new minority institution criteria contained in 10 U.S.C. 2323(a)(1)(C), which reads, in part, "minority institutions (as defined in section 1046(3) of the Higher Education Act of 1965 (20 U.S.C. 1135d-5)), which, for purposes of this section, shall include Hispanic-serving institutions (as defined in section 316(b)(1) of such Act (20 U.S.C. 1059c(b)(1)))." Portions of this pamphlet may be applicable to the research opportunities described in these specialized BAAs as well.

Each BAA specifies deadlines, proposal formats, and other unique requirements. Unnecessarily elaborate brochures or presentations beyond those sufficient to present a complete and effective proposal are not desired. All proposals must be submitted in hard copy form directly to the office listed in the applicable BAA. Be sure to mark your proposal with the specific BAA number to ensure that it receives proper consideration. Information about current BAAs is available from the address below. In addition, the *AFOSR Proposer's Guide* (AFOSR Pamphlet 64-11) describes procedures to follow when submitting proposals.

Before submitting a research proposal, you may wish to further explore proposal opportunities. You can do this by contacting the AFOSR program manager, who can provide greater detail about a particular opportunity; the program manager may then ask for a preliminary proposal (see below). However, in your conversations with any Government official, be aware that only contracting officers are authorized to commit the Government. Names and telephone numbers of AFOSR program managers are listed in Section VI of this pamphlet.

If you would prefer (or if the program manager requests), you may submit a preliminary proposal, which should be in letter format and briefly describe the proposed research project's (1) objective, (2) general approach, and (3) impact on Department of Defense (DOD) and civilian technology, as well as any unique capabilities or experience you have (e.g., collaborative research activities involving Air Force, DOD, or other Federal laboratories). Preproposal letters should not exceed three typewritten pages; example figures and a one-page curriculum vita(e) for the principal investigator(s) may be attached.

To obtain additional copies of this pamphlet and other current AFOSR BAAs, send a self-addressed label with your request to

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AFOSR publications can be obtained by calling (202) 767–4910. DOD personnel can call DEFENSE SWITCH NETWORK (DSN) 297–4910. This pamphlet, as well as other AFOSR publications, may be downloaded from the Federal Information Exchange (FEDIX), an on-line information system accessible via computer and modem. Call the FEDIX computer at (800) 783–3349 (eight data bits, one stop bit, no parity). There is no charge to the user for accessing the information. The FEDIX help line is available at (301) 975–0103 from 8:30 a.m. until 5:00 p.m. EST. Also, FEDIX is accessible via Internet at the following Telnet address: "fedix.fie.com". At login, type "fedix" or Telnet to "192.111.228.33" or to Web server http://web.fie.com/fedix/afosr.html.

* The *CBD* publishes synopses of proposed U.S. Government contract actions that exceed $25,000 in value. Subscriptions to the *CBD* are available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-9371, Tel. (202) 783–3238.

New World Vistas

The Air Force Office of Scientific Research (AFOSR) is specifically, but not exclusively, interested in sponsoring basic research that supports the science and technology areas identified in the Air Force Scientific Advisory Board's New World Vistas report. The New World Vistas report identifies science and technology needed to support six future Air Force capability areas: Global Awareness, Dynamic Planning and Execution Control, Global Mobility in War and Peace, Projection of Lethal and Sublethal Power, Space Operations, and People. The six areas have been further broken down into 41 science and technology subareas. The Air Force intends to invest in basic research that supports some or all of these subareas in the near future. These areas are described below.

Global Awareness

Point of Contact: Dr. Charles Holland, (202) 767–7899

Network Data Fusion for Global Awareness

A basic research program investigating the fundamental methods for optimizing the extraction of information and the discovery of knowledge to support military operations from ground, air, and space sensor systems, as well as from multiple intelligence and commercial data bases. The data from this wide range of sources must be combined to extract and organize information needed by war fighters and planners. Emphasis is on the development of object-oriented, symbol-based, and fusion techniques.

Lightweight Antenna Structures

A basic research program investigating the key enabling technologies necessary to support revolutionary antenna structures for advanced high-altitude radar and communications platforms. Emphasis is on advanced high-specific-strength materials with affordable processing methods to enable efficient, lightweight, reduced-observability deployable antennas, sparse apertures, and integrated structures.

Low-Cost, Lightweight Membrane Structures

A basic research program investigating the key enabling technologies necessary to support implementation of large space-deployable reflective surfaces for radar and optical apertures. Emphasis is on low-cost processing of innovative materials and coatings for lightweight membrane structures. This activity supports radar, imaging sensors, communications, laser collimators, and solar collectors and will be conducted in coordination with Precision Deployable Large Antennas/Optics.

In Situ Sensors

A basic research program investigating the key enabling technologies necessary to support implementation of stable, narrow-line semiconductor lasers operating in the ultraviolet, mid-infrared, and infrared ranges for use in unattended ground detection of nuclear, biological, and chemical (NBC) agents and for secure communication of this information. At low powers, these lasers will be used for chemical detection of NBC agents. This data will be stored until the unit is interrogated by a reconnaissance vehicle using a laser communication system. A higher power semiconductor laser will uplink to the reconnaissance vehicle.

Global Awareness Virtual Testbed

A basic research program to develop the capability to evaluate a wide range of global awareness technologies. This effort will create a multisite virtual testbed to analyze capabilities obtainable from the next generation of sensor systems. Emphasis is on development of systemwide metrics that permit measurement of information gains for sensors, communications, and fusion-processing functions. Relevant technologies include global sensor networks, global communications, multilevel fusion, commercial databases, decision aids, and information displays.

Low-Noise/High-Uniformity Broadband Sensors

A basic research program investigating the key enabling technologies necessary to support implementation of detectors for multispectral, hyperspectral, and ultraspectral sensor applications. Emphasis is on low-noise, high-quantum-efficiency, high-temperature, high-uniformity, broadband detectors. Exploration of the unique sensing systems used by biological systems, and integration of these biological concepts into electronic systems with similar capabilities, will also receive attention.

Dynamic Planning and Execution Control

Point of Contact: Dr. Charles Holland, (202) 767–7899

Planning and Scheduling

A basic research program investigating the key enabling technologies necessary to support advanced planning and scheduling systems. Emphasis is on technology related to collaborative planning and decision making, joint war fighter training, and integrated operations and on real-time intelligence, surveillance, and reconnaissance planning and scheduling that allow for degraded sensors and components. This activity provides the foundation for continuous planning in a distributed environment with multiple decision makers and for information visualization using data walls and virtual reality techniques.

Communications

A basic research program investigating the key enabling technologies that will enhance the connectivity of the aircraft to the communications grid. Emphasis is on coding; distributed computing; adaptive routing protocols; normal, efficient antenna concepts; and carrier modulation techniques. This project relates to different

aircraft tying into different networks with different waveforms using software-oriented radios.

Knowledge Bases

A basic research program supporting new classes of intelligent battlefield systems by investigating the technology to allow system developers to build large-scale knowledge bases (millions of objects) quickly and economically. The overall goal is to reduce, by a factor of 10, the time required to construct large-scale knowledge base systems.

Intelligent Agents for Air Force (AF) Battlefield and Enterprise Information Assistants

A basic research program investigating the key enabling technologies to construct the leading edge of AF-specific intelligent agents. Specific technology challenges include: (1) retrieving information from AF data bases based on AF and Department of Defense content, (2) linking AF planning tools with the large knowledge bases and data bases, (3) filtering and summarizing AF information, (4) shielding users from complexity of computer processes and interfaces, and (5) other tasks of human-machine coupling. This activity encompasses agents that perform reasoned actions as well as agents that learn their actions and controls the flood and expanse of information pouring through our networks.

Information Warfare

A basic research program investigating the most likely evolutionary paths for computer viruses and other types of malicious code. Emphasis is on the application of rigorous computer science methods with a particular focus on the threats to control code passing through an unbounded domain. The AF will make heavier use of commercial communication systems for military traffic in the decades to come. In addition, use of radiofrequency communications will increase to support theater battle management and other AF activities. Both trends offer opportunities for controlling both data and codes while in transit through an unbounded domain. This research attempts to understand how software attacks will be made and to determine the fundamental computer science issues associated with detection and prevention.

New Models of Computation

A basic research program investigating computational mechanisms such as those based on quantum computation or the use of DNA molecules or atomic-level storage and processing. Such methods may ultimately prove viable for non-real-time data fusion and scheduling applications. These applications can be modeled as combinatorial search problems in which non-real-time solutions are useful, particularly when extremely large data bases are involved. DNA calculations are realized by performing biochemical operations on molecules that represent binary sequences. While the minimum time required to complete a problem is likely to be measured in minutes or hours, the number of operations completed per unit time dwarfs that for electronic computers. The goal of this research is to determine whether these models of computation will prove viable.

Domain-Specific Component-Based Software Development

A basic research program investigating the key enabling technologies necessary to revolutionize software development time and cost by exploiting the two most promising avenues of software reuse: domain-specific architectures (DSA) and the construction of big software systems from off-the-shelf government and commercial components. DSA requires organizing and representing knowledge of function, performance (and other design parameters), equipment, and processes in AF domains. Component-based construction requires developing methods exploiting that knowledge during instantiation of DSA by components. Both methods require the development of languages for component description and component integration, including noncode assets.

Global Mobility in War and Peace

Point of Contact: Dr. Jim C. I. Chang, (202) 767–0467

Precision Air Delivery

A basic research program investigating the key enabling technologies necessary to support precision delivery of a wide range of cargo directly to the war fighter. Specific technology challenges include (1) innovative delivery platforms, such as guided parafoil systems and deployable wing systems; (2) novel materials applications, processing, and design for affordable expendable drop containers; (3) rapid deceleration methods, such as popup parachutes; and (4) affordable ballistic wind measurement systems using lidar.

Composite Materials and Structures

A basic research program investigating the key enabling materials and structures technologies necessary for the global-range airlifter and space vehicle concepts. Subprojects include the following:

(i) High-temperature materials and structures: Investigates technologies for synthesizing and characterizing novel composite materials and coatings for cooled, uncooled, and protected vehicle components that will operate in severe environments.

(ii) Lightweight materials and structures: Addresses the necessary fundamental mechanics, processing, and design issues associated with the performance of preform composite materials in aerospace applications.

Low-Specific-Fuel-Consumption Propulsion

A basic research program investigating the key enabling propulsion technologies necessary to support hyperendurance, long-range aircraft. Emphasis is on turbulence combustion modeling, ultrahigh-temperature materials, and combustion chemistry.

Aerodynamics and Controls

A basic research program investigating the key enabling technologies necessary to produce efficient cruise aircraft with lift-to-drag ratios approaching 40. Specific technology challenges include (1) active flow control and active control of nonlinear and smart structures, (2) new concepts of boundary layer control, (3) microelectromechanical systems technologies, (4) very high bypass propulsion streams and flow control, and (5) multidisciplinary optimal design.

Subsystems Integration/Power

A basic research program investigating the key enabling technologies required by advanced airlifter concepts. The key to optimizing the efficiency and performance of integrated subsystems on airlift vehicles is to develop an analytical base that enables minimization of energy used for secondary functions, including flight actuation, cargo bay pressurization, and environmental control. Thermodynamic efficiency models will be developed to characterize energy conversion and loss with advanced technologies and then to demonstrate aircraft-level performance merits of various integrated subsystem concepts.

Advanced Landing Gear

A basic research program investigating the key enabling technologies necessary to support global airlifter design and implementation. Emphasis is on tailored exploitation of alternative, lightweight, noncorroding structural materials and technologies and active and passive means of controlling serious dynamic instabilities associated with landing gear for large transport aircraft.

Microelectromechanical Systems (MEMS)

A basic research program investigating the design, fabrication, and testing of composite architectures engineered from the molecular level, incorporating new materials technology and analysis methods, including lessons learned from biological structures. New materials and processes will expand current MEMS capabilities, ultimately incorporating applications for severe environments. Methods for predicting the integrity of the interfaces between smart structures or MEMS embedded actuators and the host material will also be studied. A successful effort will enable the insertion of MEMS devices into both aging systems and new systems under development.

Active Defense Systems

A basic research program investigating the key enabling technologies for advanced air platform self-protection systems. Emphasis is on advanced technologies that will enable robust (effective against any and all threats) and affordable self-protection countermeasures. Candidate technologies include (1) high-power microwave, (2) lasers, (3) array jammers with adaptive intelligence, (4) plasma cloaking for hypersonic vehicles, (5) aircraft kinetic kill, and (6) radar cross-section reduction using both active and passive technologies.

Battlefield Awareness/Weather Predictions

A basic research program investigating the key enabling technologies necessary to enhance battlefield awareness. The systems include integration of data within the cockpit for use by the war fighter and data communicated from the aircraft to the battlefield for use by commanders and off-aircraft systems.

Human Systems Interface and Training

A basic research program investigating the key enabling technologies to develop and demonstrate uninhabited combat aerial vehicle (UCAV) operator system concepts. This research includes the training requirements and methods necessary to effectively use the UCAV operator-vehicle interface in combat scenarios. Emphasis is on UCAV-like laboratory task performance analysis and modeling, leading to operator station concepts and training paradigms.

Projection of Lethal and Sublethal Power

Point of Contact: Dr. Jim C. I. Chang, (202) 767–0467

Family of Uninhabited Aerial Vehicles (UAVs)

A basic research program investigating the key enabling technologies necessary to support the whole family of potential uninhabited reconnaissance aerial vehicles and UCAV concepts. Subprojects include the following:

(i) High-efficiency, low-cost propulsion and power: Investigates technologies needed to provide the high fuel efficiency and energy storage for hyperendurance, high-altitude vehicles. The propulsion design options between fully person-controlled rated and expendable engines will be thoroughly explored. Ultrareliable, efficient, high-power-density power generation methods and energy storage materials will be considered.

(ii) Distributed architecture and high-bandwidth data exchange: Investigates the combination of flexibility, high capacity, jam resistance, data links, distributed architectures, and processing networks necessary for commanders to control multiple UAV functions or squadrons of UAVs.

(iii) Weaponization: Investigates small affordable munitions for UAVs to perform a wide range of lethal missions. Both directed- and kinetic-energy options merit additional study. Specific technology challenges include (1) high-energy-density propulsion, (2) high-energy and nonconventional warheads, (3) hardened missile dome materials, (4) small, multispectral modular seekers, (5) selectable warhead and propulsion profiles, (6) offensive and defensive laser and high-power microwave (HPM) directed-energy weapons, and (7) hypervelocity guidance and control.

(iv) High-strength, lightweight structures and materials: Investigates the innovative design and manufacturing of very low cost, high-strength structures and materials necessary to fully exploit the high performance levels permitted by removing the pilot's physical presence; to enable uncooled, high-cycle temperatures and simplified vehicle design; and to significantly improve the potential for affordable systems.

Hypersonics

A basic research program investigating the key enabling technologies for hypersonic propulsion systems. Subprojects include the following:

(i) Flow field research: Electromagnetic manipulation of ionized flow fields may offer potential for improving hypersonic vehicle lift-to-drag ratios and for tailoring inlet flow fields and rocket nozzles. Understanding the physical phenomena involved in these processes may lead to very effective long-range vehicles with reduced aerodynamic heating loads. The current state of modeling capability lags that of other flight and propulsion technologies. Key requirements for viable models include (1) simplified models for fuel-air combustion chemistry, (2) models for turbulence-chemistry interactions under high-speed compressible flow conditions, and (3) models for high-speed aerodynamics. Assessments of candidate vehicle configurations must be based on actual mission performance criteria. Major issues include (1) vehicle drag variation, (2) scram-jet inlet performance, (3) coupled engine-airframe performance under actual dynamic maneuver mission scenarios, and (4) combined cycle combustion.

(ii) Advanced propulsion: Investigates advanced propellants and cooling concepts to enable hypersonic Mach 8+ aeropropulsion and combined cycle propulsion. Hydrocarbon-fueled vehicles in sustained hypersonic flight will involve substantial heat transfer to the fuel prior to injection into the scram-jet combustor. The design of the rockets and airbreathers will require combustion systems with the flexibility to inject and mix supercritical fluids as liquids, two-phase mixtures, or vapors. This requirement is unprecedented in conventional system designs. In addition, flight beyond Mach 8 with storable propellants may require innovative fueling and cooling approaches.

Lethal and Sublethal Directed-Energy Weapons

A basic research program investigating the key enabling technologies necessary to support the fotofighter concept, directed-energy force projection from and in space, and compact HPM lethal and sublethal weapons. Subprojects include the following:

(i) Phased arrays of semiconductor laser diodes: Investigates the fundamental technology for the fotofighter concept. Specific technology challenges include the development and demonstration of (1) scalable coherent arrays, (2) techniques for electronic beam steering and target tracking, and (3) laser integration concepts that support very high efficiency, lightweight designs for conformal mounting and operation.

(ii) Large, lightweight optics wavefront compensation: Investigates fundamental technologies required to engage terrestrial targets with lasers from space. Materials, structures, and designs for very large inflatable or membrane mirrors must be coupled with advanced mechanical control and advanced optical techniques for wavefront correction. Advanced optical materials, adaptive nonlinear optics, Brillouin enhanced four-wave mixing, and adaptive mirrors will be investigated for correction of laser beam distortion.

(iii) Lightweight, efficient microwave components: Provides the fundamental tools and the physics and technology data base necessary for the development of HPM directed-energy weapons for space and UCAV applications. Specific technology and science challenges include (1) the creation and evolution of plasmas under the influence of high-power electromagnetic fields, (2) ultrawideband sources of microwave radiation, (3) the optimization of antennas required to efficiently project microwave power, both narrowband and ultrawideband, and (4) the physics and technology of frequency agile narrowband HPM sources.

(iv) Compact high-voltage pulsed power: Investigates the fundamental enabling technology required for packaging several types of directed-energy weapons. Specific basic research topics include (1) investigation of high-power-density, low-mass opening and closing switches and transformers, (2) flux compression generators employing conducting shock-front armatures, and (3) novel high-energy-density storage technology and techniques for rapid energy release.

(v) Bioeffects: Investigates the biological effects of novel directed energy emissions in both acute and chronic exposure conditions. The effects of pulse shapes, modulation schemes, peak power, and other parameters of directed-energy weapons systems on biological organisms will be studied.

Energy-Coupling Modeling and Simulation

A basic research program investigating the key enabling technologies necessary to support smarter, more precise, autonomous, all-weather, highly lethal weapons with minimal collateral damage. Emphasis is on modeling of (1) coupling of warhead energy into targets to multiply lethality, including exotic or unconventional kill mechanisms; (2) penetrating munition terradynamics (penetration physics and munition steering); and (3) initiation physics of energetic materials.

Space Operations

Point of Contact: Dr. Horst R. Wittmann, (202) 767–4984

Microsatellites

A basic research program investigating the key enabling technologies necessary to support implementation of small, single-function, low-cost satellites with short build-to-launch times. Technology challenges include (1) lightweight, deployable precision structures; (2) hardened, low-power microelectronics; (3) thermal control for single-chip operation; (4) onboard processing and large onboard data storage systems; and (5) low-power microelectric propulsion for precision station keeping and position changes.

Distributed Functionality

A basic research program investigating the key enabling technologies necessary to support distributed satellites and related communications systems, both airborne and ground-based. Specific technology challenges include (1) distributed synthetic aperture sensor systems for resolution enhancement, (2) pointing concepts and optimization of collateral systems, (3) survivability of distributed microsatellite systems, (4) autonomous control of satellite clusters, (5) layout and control of distributed systems, (6) satellite network functionality, and (7) lightweight, high-data-rate cross-links.

Precision Deployable Large Antennas/Optics

A basic research program investigating the key enabling large-aperture technologies required for target identification and directed-energy delivery from space. Emphasis is on addressing the physical size, system quality, and alignment limitations, as well as creating concepts for compact, lightweight, compensated, deployable precision reflectors. The program brings together innovations in optical compensation, deployment concepts, smart mechanisms, ultralight reflector panels, and precision metrology. Key issues include (1) precision pointing stability, (2) directionality, (3) beam control, and (4) maximum obtainable resolution.

High-Efficiency Electrical Laser Sources

A basic research program investigating the key enabling technologies necessary to support engaging terrestrial targets with lasers from space. Emphasis is on enhancing the coherency, stability, and power handling capability of high-efficiency, high-power semiconductor lasers. High-efficiency laser sources will be designed and packaged for space operation.

Space Object Identification and Orbit Prediction

A basic research program investigating the key enabling technologies necessary to identify space objects that are threats to operations in space and to the earth. Emphasis is on reliable and accurate determination of the trajectory (orbit) of space objects.

High-Energy-Density Propellants

A basic research program investigating the key enabling propellant design technologies necessary to support low-cost reliable access to space. Improved rocket propulsion capabilities are required to make space vehicles affordable and to ensure rapid vehicle turnaround. Emphasis is on innovative, practicable approaches to utilize emerging high-energy-density materials that will enhance overall space vehicle capability.

Jam-Proof, Area-Deniable Propagation

A basic research program investigating the devices, algorithms, and propagation techniques necessary to deny the adversary precision navigation, metrology, and communications while ensuring that this information is available to friendly forces.

Nanosecond Global Clock Accuracy

A basic research program investigating the use of optical laser frequencies for timing stabilization. One approach is to perform spectroscopy experiments with new intracavity saturation spectroscopy to determine the pressure-broadened sub-Doppler linewidths critical for high-precision line locking of lasers (i.e., ultrafrequency accuracy and stability).

Hypervelocity Dynamics

A basic research program investigating the key enabling technologies necessary to optimize space vehicle performance. Emphasis is on flight control, flight vehicle, mission status, aerodynamics (energy coupling, modeling, and simulation), aerodynamic and control technologies, and innovative engine and airframe integration (using hypervelocity computational fluid dynamics).

Low-Cost, Lightweight Structures and Materials

A basic research program investigating the key enabling technologies necessary to reduce satellite and space vehicle mass by using low-cost, lightweight structures and materials. Emphasis is on enhancing the durability, maintainability, and multifunctionality of lightweight designs for propulsion components, thermal protection systems, cryogenic tanks, and structures.

Power Generation and Storage

A basic research program investigating the key enabling technologies necessary to provide the power generation and storage required by distributed satellites and space vehicles. Specific technology challenges include (1) high-efficiency, lightweight, low-cost, high-energy-density power generation systems such as high-efficiency solar cells, concentrator arrays, and thermal or solar devices; (2) high-efficiency power management systems; and (3) high-density, lightweight power storage systems such as capacitors, batteries, and high-efficiency flywheels. Advanced magnetic and superconducting approaches will be studied.

People

Point of Contact: Dr. William O. Berry, (202) 767–4278

Human-Machine Interface

A basic research program investigating the key enabling technologies necessary to enhance human-machine interfaces. Emphasis is on several areas related to the design of novel interfaces. New measures of individual cognitive workload will be studied for use in monitoring performance degradation in response to stress and fatigue and for establishing benchmarks for alternative interface systems. Studies of multisensory interaction (i.e., auditory, visual, vestibular) will be used to establish standards for development of augmented displays such as virtual reality or helmet-mounted systems. Models of individual real-time knowledge state will be developed to enable technologies of adaptive interfaces and interfaces with embedded training capability. Analysis of system scale performance of operators will be conducted to support modeling and simulation of factors affecting human performance related to interface design.

Team Decision Making

A basic research program investigating the key enabling decision-aiding technologies in support of command and control. Emphasis is on analysis of team performance as a complex decision-making system comprising multiple human and automated agents. This effort takes advantage of synthetic tasks (i.e., laboratory extrapolations of real-world tasks) to identify the strategies used by intelligent agents (which are modeled on human agents) to analyze the stability and robustness of communication patterns in teams faced with increasing flows of information.

Cognitive Engineering

A basic research program investigating design-support technologies. Emphasis is on quantitative measures of human performance in complex tasks such as piloting of air and space vehicles. Cognitive task analysis is used to determine critical points in vehicle operation; critical tasks are embedded in research settings where the sensitivity of human performance to design variants can be quantified; basic models of performance tradeoffs then will be critically examined in facilities for assessing pilot performance.

AFOSR is inviting submission of basic research proposals in response to these New World Vista science and technology needs. Those interested are strongly encouraged to contact the points of contact shown above for additional information prior to submitting proposals specifically directed at these areas. Additional background information may be obtained from the Air Force Scientific Advisory Board's New World Vistas report summary volume. It can be found at the World Wide Web address http://web.fie.com/htdoc/fed/afr/sab/edu/text/any/afrtnwv.htm. (Web addresses occasionally change. If you cannot find the New World Vistas site at this address, contact AFOSR/XPP at (202) 767–5015 for assistance.) Proposals specifically directed at New World Vistas areas should be identified as such and should reference the specific New World Vistas area.

III

Research Interests

Aerospace and Materials Sciences

The Directorate of Aerospace and Materials Sciences is responsible for research activities in aerospace, engineering, and materials. The four major projects in the directorate are solid mechanics and structures, structural materials, fluid dynamics, and propulsion. An equally important mission of the directorate is to support multidisciplinary efforts to meet Air Force science and technological needs. The structural materials activities in the directorate and the chemistry activities supported by the Directorate of Chemistry and Life Sciences make an integrated Air Force Office of Scientific Research (AFOSR) structural materials program. The control theory and mathematical modeling research supported by the Directorate of Mathematics and Geosciences complements many structural, fluid mechanics, and propulsion research programs supported by this directorate.

Structural Mechanics

The objective of this research program is to study solid mechanics fundamentals and structural principles that are necessary to ensure the integrity of current and future aerospace structures, including aircraft, missiles, and spacecraft. Proposals are sought that will lead to a fundamental understanding of the behavior of structures that are composed of current metallic materials as well as advanced composite materials. Proposals are also sought that will develop principles to predict nonlinear aerospace structural characteristics under coupled fluid, thermal, and mechanical loads. We are interested in solid mechanics principles that govern nonlinear coupled deformation and damage mechanisms that dictate anisotropic and heterogeneous medium response and structural performance. Topics such as damage localization, instability formation, homogenization, energy dissipation, and local and global response correlation are of interest. Structural nonlinear behavior and control owing to coupled mechanical, fluid, acoustic, and thermal loads are important to the design and performance prediction of aerospace systems. Fluid-structure interaction, aerothermoelasticity, and the development of intelligent materials and structures are of interest to this program. The degradation of materials and structures over long periods of service is also of interest, since current Air Force weapon systems will remain in service much longer than originally anticipated. This research includes the prediction of material degradation under combined mechanical and environmental loads, as well as the nondestructive detection and quantification of internal damage (e.g., corrosion, fatigue cracking).

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Mechanics of Materials

Research in this program seeks to establish the fundamental understanding required to design, process, and predict thermomechanical performance of aerospace structural material systems. Projected Air Force applications will require multifunctional material systems capable of sustained performance in extreme loading environments. Candidate structural material systems are almost all highly heterogeneous, composite media. These systems include metallic and intermetallic alloys, advanced composite material systems (including polymer-matrix, metal-matrix, ceramic-matrix, and carbon-carbon composites), and solid rocket propellants and liners. Innovative new material systems, such as nanostructural materials and functionally graded materials, are also of interest.

The continued development of safer, more durable aerospace vehicles with improved performance characteristics depends on researchers' ability to understand, characterize, and quantitatively model the expected behavior of such emerging material systems. Therefore, this program focuses on developing and applying appropriate mechanics principles and methodology to treating advanced materials. Particular emphasis is placed on material systems that are capable of operating in extreme-temperature environments, such as those to be used in future engine and airframe component designs. Quantitative connections between evolving microstructural features and resulting performance parameters must be established, along with an analytical understanding of the relationship between processing and microstructure. Interdisciplinary approaches that include mechanics, materials science, chemistry, physics, and applied mathematics are encouraged, as are combined analytical-experimental efforts. Interaction with Air Force laboratory researchers who are conducting basic research is also encouraged, as is interaction with Air Force personnel in exploratory and advanced development programs.

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Particulate Mechanics

Particulate mechanics research aims to develop a fundamental understanding of the behavior of civil engineering materials (e.g., soil, rock, concrete) and their response to static and shock loading. Civil engineering materials, or particulate materials in general, can be represented as an assemblage of physically discrete particles—either alone or in a matrix of materials having significantly different properties. The developed mechanics can also provide insight into the behavior of the powders and dense suspensions used in manufacturing

advanced aerospace materials. Research in this program also seeks to understand the fundamental physical and chemical mechanisms governing fluid flow in porous media.

Present-day constitutive models for civil engineering materials are based on empirical relationships derived from phenomenological data. These models fail to address the multitude of factors affecting the behavior of these inherently complex, heterogeneous, anisotropic, multiphasic materials systems. Only through a sound understanding of the microstructural interactions of system components will it be possible to predict the mechanical behavior and performance of these particulate materials. This is true whether one is studying the long-term performance of airfield pavements or the shock physics of an explosion propagating through a weapon, the ground, or an enemy target. This research will provide a knowledge base from which mechanical models can be developed to design future civil engineering structures, as well as predict the performance of existing structural systems, which in turn will lead to more reliable, lethal, and survivable aerospace systems.

Proposals for research in particulate mechanics should emphasize the behavior of particulate material systems, with characteristic lengths ranging from nanometers to meters. We seek to obtain quantitative relationships that describe the static and dynamic behavior of these systems. Interdisciplinary theoretical, analytical, or experimental approaches that include mechanics, materials science, physics, and applied mathematics are encouraged. Proposed research in this area should focus on the influence of material microstructure on the overall constitutive behavior of multiphasic (heterogeneous) particulate systems, localization and instabilities in particulate media, and the high-deformation, high-strain-rate behavior of particulate material systems.

Closely related research seeks an understanding of the physical and chemical processes that govern flow in porous media, particularly as it applies to contaminant fate and transport problems in environmental quality research. A better understanding of the fate and transport of current and future Air Force contaminants (e.g., fuels, solvents and lubricants, solid rocket propellants) is required. Interdisciplinary theoretical, analytical, or experimental approaches that include mechanics, chemistry, physics, and applied mathematics are encouraged. Research in this area should focus on the effect of porous media structure, sorption/desorption mechanisms, and the presence of nonaqueous phase liquids and gases on fluid flow and contaminant transport in porous media.

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External Aerodynamics and Hypersonics

This research program seeks to improve the understanding of viscous and inviscid fluid-flow phenomena that strongly influence the mission requirements–driven design, aerodynamic performance, and efficiency of Air Force flight vehicles. This program comprises three technical areas: advanced computational fluid dynamics (CFD), unsteady aerodynamics, and hypersonics. Research should focus on the underlying physical mechanisms that govern these classes of complex flows.

Research in advanced CFD is sought to develop autoadaptive, unstructured grid methods. Currently methods of simulating the complex, three-dimensional, time-dependent flows created by aircraft and missile platforms during dynamic combat maneuvers are being researched. Research is also sought to address flows with multiple bodies in relative dynamic motion, such as store separation. These full Navier-Stokes simulations include viscous effects that range from laminar, through transitional, to fully turbulent boundary layer states. Of particular importance is the development of advanced large-eddy simulation (LES) and direct numerical simulation (DNS) methods for high-speed, viscous, compressible flows over aircraft and missile components (wings/fins and fuselages), as well as internal flows in supersonic engine inlets and hypersonic SCRAMJET inlet systems. LES methods using spectral element or other DNS subgrid scale simulations are of particular interest. We are also interested in developing analytical capabilities for dynamic, three-dimensional, viscous, hypersonic engine inlet unstart processes.

Research in unsteady aerodynamics should reveal the fundamental viscous processes associated with vorticity generation within the boundary layer along wing leading edges, the mechanisms responsible for the transfer of that vorticity through feeding sheets from within the boundary layer into discrete vortices outside the boundary layer, and the convection of those vortices once they are shed from the boundary layer into the free-stream flow around and beyond the wing. Research to identify the influence of wing leading edge geometry and aircraft motion on these processes is also sought. It is critically important to develop nondissipative CFD algorithms that are capable of tracking multiple shed vortices with no diffusive loss of vorticity. This includes phenomena related to vortex convection, vortex surface impingement, and multiple vortex coalescence.

Research in hypersonics should improve the understanding of complex, time-dependent, three-dimensional viscous flows with and without finite-rate chemistry effects, and should advance the accuracy of high-altitude numerical simulation methods. We are especially interested in three-dimensional, Burnett equation numerical methods. Boundary layer stability and transition analyses for flows over hypersonic flight vehicles based on the

Burnett equations are of particular interest. DNS methods with rate chemistry are also sought. We are also interested in shock tunnel research that investigates the fundamental fluid mechanics of high–Reynolds number as well as high-enthalpy hypersonic flows in realistic flight conditions. New concepts for hypersonic, high-enthalpy, and high–Reynolds number shock tunnels are of particular interest.

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Turbulence and Internal Flows

Research in turbulence and internal flows is primarily motivated by Air Force requirements for airbreathing propulsion systems and advanced flight controls. In this context, the program seeks to advance fundamental understanding of the complex, unsteady flows occurring in gas turbine engines, and to apply that understanding to the development of physically based predictive models and innovative concepts for controlling complex internal flows. The program also addresses a broader class of flow control problems related to generic technologies such as fluidic thrust vectoring, internal flow tailoring, high lift, enhanced mixing, noise and signature reduction, aero-optics, aeroacoustics, drag reduction, electronic cooling, compressor stability, heat transfer, and thermal management.

Primary emphasis is placed on understanding and controlling fundamental flow processes using active flow control approaches, including the exploration of emerging microlectromechanical systems (MEMS) technology for aerodynamic measurement and control. A particular challenge is the exploration of innovative actuator concepts for fluidics-based flow and flight control strategies. We are also interested in ideas exploring frontiers in fluid mechanics relative to fundamental flow processes occurring in microscale devices and systems, and in the potential for MEMS-based approaches to the control of microscale flows relative to electronic cooling and materials-processing technology. The exploitation of pattern formation in excitable media may lead to innovative direction in materials-processing fluid mechanics.

Research contributing to the understanding of flow instabilities and the mechanisms of transition from laminar to turbulent flow in both bounded and free-shear flows is of interest—especially the receptivity of linear and nonlinear transition processes to background and imposed flow disturbances—as is the impact on flow controllability.

Improved turbulence modeling approaches are sought for the prediction of flow and heat transfer in highly strained and unsteady turbulent environments (e.g., gas turbine engines). In this context, we seek original ideas for modeling turbulent transport, especially ideas for incorporating the physics of turbulence into predictive models. We are also interested in improved subgrid models for LES methods, especially in the near-wall region. High quality turbulent flow data relevant to the advancement of transport and subgrid models for high–Reynolds number turbulent flows are also of interest.

Research that addresses fundamental flow phenomena occurring in gas turbine engines, emphasizing the roles of unsteadiness and three-dimensionality in determining the performance, stability, and heat-transfer characteristics of these internal flows, is encouraged. Active control strategies for rotating stall and surge instabilities in gas turbine engine compressors are of interest. Of particular concern is the phenomenon of unsteady flow–induced forced blade response and its impact on high-cycle fatigue of turbine engine components.

Another principal concern is the prediction and control of heat transfer in gas turbines, including the effectiveness of both film-cooling and internal-cooling flows. The principal areas of interest include blade wake effects, shock impingement effects, high free-stream turbulence, stagnation-point heating, blade tip clearance flows, blade hub juncture flows, and transition heat transfer phenomena.

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Airbreathing Combustion

Fundamental understanding of the physics and chemistry of multiphase, turbulent reacting flows is essential to improving the performance of airbreathing propulsion systems. We are interested in innovative research proposals that use simplified configurations for experimental and theoretical investigations.

Our highest priorities are studies of supersonic combustion, atomization and spray behavior of slurries and liquids, fuel combustion chemistry, and supercritical fuel behavior in precombustion and combustion environments. Other topics of interest include turbulent combustion, soot formation, and interactive control.

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Space Power and Propulsion

Wide-area surveillance and space-based defense require affordable, on-demand, on-schedule launch and orbit transfer vehicles as well as accurate plume prediction models.

Research activities fall into three areas: nonchemical orbit-raising propulsion, chemical propulsion, and plume signatures/contamination resulting from both chemical and nonchemical propulsion. Research in the first area is directed primarily at advanced space propulsion, and is stimulated by the need to transfer payloads between orbits. It includes studies of the sources of physical (nonchemical) energy and the mechanisms of release. Our emphasis is on understanding electrically conductive flowing gases (plasmas) that serve to convert beamed or electrical energy into kinetic form. Theoretical and experimental investigations are being conducted on the phenomenon of energy coupling and the transfer of plasma flows in electrode and electrodeless systems under plasma dynamic environments.

Topics of interest include characteristics of pulsed and steady-state plasmas; scaling physics; characteristics of equilibrium and nonequilibrium flowing plasma; characteristics of electrical and hydrodynamic flows; instabilities of plasma bulk and wall layers; interactions of plasma-surface, -electrode, -magnetic, and -electric fields; losses to inert parts; characteristics of plasmas in high-magnetic fields and pressures; and plasma diagnostics (new and unique noninterfering measuring techniques).

Research is being conducted on chemical propulsion to predict and suppress combustion instability in solid and liquid rocket systems to control the complex role of advanced energetic ingredients in solid propellant burning.

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Metallic Structural Materials

The goal of research in metallic structural materials is to provide the fundamental knowledge required to develop metallic alloys and composites for aerospace applications. Potential applications of these materials include turbine airfoils and disks, engine casings and nozzle components, airframe and spacecraft structural components, and hypersonic vehicle skins. Improved metallic structural materials will be capable of operating at higher temperatures with significantly reduced densities as compared with currently available materials.

This goal will be accomplished by understanding the relationships between processing, chemistry, and structure on the one hand and properties of metallic and metallic composite materials on the other. Specific scientific topics include the development and experimental verification of theoretical and computational (atomistic) models, processing science, phase transformations, interfacial phenomena, strengthening mechanisms, plasticity, creep, fatigue, environmental effects, and fracture of structural metallic materials. Materials currently under research include refractory metals, intermetallic alloys, metal-matrix composites, intermetallic-matrix composites, amorphous alloys, and microlaminated materials.

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Ceramics and Nonmetallic Structural Materials

The objective of this research program is to provide scientific background for current and future Air Force-related applications of ceramics, ceramic-matrix composites (CMCs), and carbon-based composites. One major component of this objective is to increase our understanding of high-temperature strength and creep resistance of ceramic materials at the atomic and microscopic levels. This basic knowledge is necessary to develop reliable, creep-resistant, and affordable ceramics for high-temperature structural applications that will improve propulsion and vehicle performance. Of particular interest are creep-resistant oxide materials (e.g., yttrium aluminum garnet, alumina, zirconia). In addition, silicon nitride, silicon carbide, and other refractory nonoxide ceramics are being investigated for very high temperature applications.

One of the major detriments to using ceramics for structural applications is their brittleness. This program addresses how to reduce or control the brittleness of ceramics in three ways: (1) by studying the fracture, fatigue, and reliability of ceramics, thereby providing criteria for predicting their performance under a variety of conditions; (2) by evaluating transformation toughening, flaw- and stress-induced toughening, and other techniques of increasing toughness; and (3) by designing, fabricating, and evaluating fiber, laminate, and particulate CMCs that fracture in a metal-like, "graceful" manner. It is expected that fiber-reinforced CMCs will satisfy requirements for tough, reliable materials capable of prolonged operation at and above 2,700 degrees Fahrenheit (1,500 degrees Celsius). To meet these goals, this program emphasizes research efforts on oxidation-resistant, thermally stable, fiber-matrix interfaces; optimization of strength of fiber-matrix interfaces; and novel processing techniques that improve the performance and affordability of CMCs.

Lightweight, high-temperature-resistant carbon-carbon composites are increasingly used as structural elements for hypersonic aircraft and space structures. To facilitate their use, these materials' resistance to oxidation must be improved. Thus this program seeks to elucidate oxidation mechanisms of carbon materials, with the goal of inhibiting oxidation by using dopants and surface modifiers. Also being studied are carbonlike materials

that resist oxidation better than carbon (e.g., BC3). In addition, new approaches to oxidation-inhibiting coatings for carbon-carbon composites are being sought.

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Organic Matrix Composites

This program addresses the materials science issues relating to the use of polymers in aerospace and space structures (e.g., airframes, engine components, rocket motors, satellites). The goal is to provide the scientific base that will lead to higher performance, more durable, more affordable structures for Air Force applications. This task is consistent with the future global mobility and space operations capabilities outlined in New World Vistas. The current approach emphasizes studying the development of improved performance or lower cost polymer-matrix composite (PMC) systems and the processing and use of these structures during deployment. The chemistry and processing of structural adhesives and polymeric precursors for ceramic and carbon-carbon structures are also within the scope of this program. Materials science issues relating to all material preforms and processing leading to the end components are of interest. Examples of these include resin chemistry and formulations, prepregs processing, dry preforms, layups, and cure processes.

The current program emphasizes research on the effects of certain environments on the durability of PMCs. These include a harsh processing environment (e.g., high-temperature processing), application environments (e.g., high-temperature exposure under pressurized conditions), and service environments (e.g., moisture, solvents). Research will address the chemistry and physics of the degradation mechanisms that lead to deterioration in the performance of the PMC structures. The scope will cover the matrix, reinforcement, interphase, and composite as a whole. The results of this research will lead to accurate prediction of PMC structures' service life and to alternative material systems, processing procedures, and service practices that can increase the service life of these structures.

High-temperature and/or low-shrinkage adhesives are needed to improve the performance of high-temperature components and adhesive-bonded joints. New nondestructive evaluation methods that will probe chemical bonding integrity instead of macroscopic damage are of interest. An understanding of the kinetics and mechanisms of chemical degradation and physical aging of adhesive-bonded joints is also sought.

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Physics and Electronics

Research in physics and electronics generates the fundamental knowledge needed to advance Air Force operational capabilities in surveillance; guidance and control; information and signal processing; and communications, command, and control. The program is of substantial breadth, extending from elementary and quantum physics, to the understanding of the performance of novel electronic devices, to engineering issues such as those found in electronic or photonic systems or materials-processing techniques. One main objective of the program is to balance innovative science and Air Force relevance, the first element being forward looking and the second being dependent on the current state of the art. Included in our core program is the Joint Services Electronics Program (JSEP), a joint undertaking of the Army, Navy, and Air Force to support synergistic, multidisciplinary, multi-investigator projects at universities in the fields of electronics and related sciences. Broadly interpreted, research areas of JSEP include solid-state electronics (devices, materials, integration), quantum electronics and optics, electromagnetics (propagation, waveguides, scattering antennas), and information electronics (circuits and systems, communications, signal processing, computers), together with interdisciplinary programs in physics, chemistry, mathematics, materials science, and engineering. Research areas of interest to the Air Force program managers are described in detail in the following subareas. Office of Naval Research and Army Research Office Broad Agency Announcements (BAAs) should also be consulted. Information on eligibility for support under JSEP can be obtained from the Executive Secretary, JSEP, U.S. Army Research Office, PO Box 12211, Research Triangle Park, NC 27709-2211, (919) 549–4345. Multidisciplinary information can be obtained from Maj William Arrasmith, AFOSR/NE, (202) 767–4907, DSN: 297–4907, FAX: (202) 767–4986, E-mail: william.arrasmith@afosr.af.mil.

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Electromagnetic Devices

This research program encompasses approaches to active and passive elements for high-speed, high-bandwidth analog applications (e.g., phased array radar systems). One emphasis of the program is the growth, study, and applications of nonstoichiometric compound semiconductors (e.g., As-rich GaAs). Research is sought on a physical model explaining the electronic and optoelectronic properties of these materials and an understanding of the relative roles played by point defects and extended defects, such as As precipitates. Extensions to other nonstoichiometric materials systems (e.g., the antimonides) are of interest. Efforts continue in the modeling and characterization of Microwave and Millimeterwave Integrated Circuits (MMIC) (particularly passive) elements.

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Novel Electronic Components

Novel material and device approaches are sought for application to high-temperature, high-rf power electronic systems. Of particular promise are the III-N materials (e.g., GaN, InGaN) and related electronic devices. The primary focus is on high-temperature applications of nitride-based electronic devices. Another emerging class of electronic devices are those seeking to exploit the so-called "wet Al-oxides" formed by the steam oxidation of AlAs and high Al-content AlGaAs layers. In both the nitride and Al-oxide cases, fundamental materials studies as well as electronic device applications are of interest. There is a continuing need for long-wavelength infrared (IR) imaging devices and systems.

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Optoelectronic Information Processing: Devices and Systems

This program includes investigations in two affiliated areas: (1) the development of optoelectronic devices and supportive materials, and (2) the insertion of these components into optoelectronic computational and information-processing systems. Device exploration and architectural development for processors are coordinated; synergistic interaction of these areas is expected, both in structuring architectural designs to reflect advancing device capabilities and in focusing device enhancements according to system needs.

Research in optical materials and optoelectronic devices emphasizes the insertion of optical technologies into computing, image-processing, and signal-processing systems. To this end, this program continues to foster surface-normal interconnection capabilities, combining arrays of sources or modulators with arrays of detectors, with both being coupled to local electronic processors, often in "smart pixel" configurations. Support has recently been established for ultra-low-threshold Vertical Cavity Surface Emitting Lasers and the concomitant attributes of microcavity laser devices. This area includes prospects for intersubband lasing and the coupled photon-exciton dynamics of small-volume, high-Q cavities.

Looking ahead, funds are being sought to support high-efficiency, low-power photoreceivers that operate at

bandwidths exceeding 100 MHz and require fewer than 5,000 photons per bit. A related program thrust explores optical memory technologies that support page-oriented or holographic configurations. Capabilities of persistent spectral hole-burning systems for memory, as well as for processing, anchor this thrust. The spatiospectral attributes of this technology link "free-space" interconnect concepts to those of multispectral systems. Devices are being developed that emit, modulate, transmit, filter, switch, and detect multispectral signals, for both parallel interconnects and quasi-serial transmission.

Understanding the fundamental limits of the interaction of light with matter is important for achieving these device characteristics. Semiconductor materials and structures are the basis for the smart pixel technologies. Inhomogeneously broadened, generally cryogenic, optically resonant materials support the memory development. General themes for acceptable device approaches include high-bandwidth interface, low-energy consumption, demonstrable parallel access, and gain, logic, or memory attributes with prospects for array configurations.

System-level investigations incorporate these devices into processing architectures that exploit their demonstrated and envisioned attributes and determine appropriate problem classes for optical and optoelectronic approaches. The computational advantages and proper use of parallelism provided by optical implementations continue to guide architecture development. For example, the elimination of turbulence-induced distortions from image wavefronts using parallel processors is a current thrust, as is the implementation of parallel compression and forward error correction techniques for storage or transmission of imagery. Computer interconnections continue to encounter increasing difficulty in signal transmission constrained by wire-crossing layout restrictions, electromagnetic interference, and cross-talk—impediments that may be circumvented by optical interconnect approaches. Illustrative is the time-honored Von Neumann bottleneck in memory-to-processor data transfers; parallel access capability promised by optical technology may ameliorate this constriction. Alternatively, a second program thrust emphasizes the use of the inherent, extremely high bandwidth of optical carriers by investigating systems that use multispectral data representations. Presently this thrust focuses on the incorporation of multispectral devices into transmission routing nodes to decrease latency and manage contention. Based on this prototypical application, future systems may satisfy computational functionalities.

One architectural problem currently being investigated is high bandwidth parallel optoelectronic interconnects between parallel electronic computers. In addition, optical access and storage physics in memory devices are being pursued to obviate capacity, access latency, and input/output bandwidth concerns. Another focus is on spectral domain processing to perform terabit-per-second multiplexing as well as data packet routing and byte-parallel transmission. A multidisciplinary research demonstration platform applies both device and architectural capabilities to aero-optic diagnostics, image processing, and wavefront correction in aerodynamically turbulent environments in concert with program thrusts resident in AFOSR aerodynamics and mathematics directorates.

This program supports Air Force requirements for information dominance by increasing capabilities in image capture; processing, storage, and transmission for surveillance; target discrimination; and autonomous navigation. In addition, high-bandwidth interconnects enhance performance of distributed processor computations that provide real-time simulation, visualization, and battle management environments.

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Quantum Electronic Solids

This program focuses on materials that exhibit cooperative quantum electronic behavior, with the primary emphasis on superconductors—and any conducting materials with surfaces that can be modified and observed through the use of scanning tunneling—and related atomic-force microscopies. The program also focuses on device concepts using these materials for electromagnetic detection and signal processing in Air Force systems.

The long-standing materials aspects of the program are based on the fabrication, characterization, and electronic behavior of superconducting thin films, which ultimately can lead to the discovery of new and improved electronic circuit elements. Two main objectives are to understand the mechanisms that give rise to superconductivity in selected ceramics and to produce high-quality Josephson tunneling structures. There also is increasing interest in finding superconducting behavior in other families of materials, with the hope of discovering such behavior at higher temperatures. Recently the program has been expanded to include bulk superconducting materials that can be useful in producing current-carrying wires in power applications. A continuing interest in this program is the search for new electronic device concepts that involve superconductive elements, either alone or in concert with semiconductors and normal metals; there is also interest in understanding high-power absorption in high-temperature superconducting materials at microwave frequencies.

A minor aspect of this program is the inclusion of scanning probe techniques to fabricate, characterize, and manipulate atomic-, molecular-, and nanometer-scale structures, with the goal of producing a new generation of

improved sensors, resulting in the ultimate miniaturization of analog and digital circuitry.

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Semiconductor Materials

Air Force optoelectronic signal processing, communications, surveillance, and electronic warfare systems require continual improvements in performance. This research project is directed toward developing advanced semiconductor materials to provide those required improvements in future Air Force systems, thereby enhancing the effectiveness of tomorrow's warfighters. In particular, we seek to generate the fundamental knowledge and the materials data base required for the growth and use of novel, as well as existing, optoelectronic and electronic materials and structures. No single material has the combination of properties required for all applications, so several classes of single-crystal semiconductors—including a variety of heterostructure combinations—are currently under investigation. Similarly, quantum-well semiconductor heterostructures are also being studied.

Compound semiconductors and heterostructure combinations of such materials are the foundation of new generations of wavelength-diverse, highly efficient optoelectronics and ultra-high-speed digital electronics. These materials provide the properties necessary for advanced information- and signal-processing applications and optoelectronic communication systems for a future command and control infrastructure. We are currently investigating compound semiconductors for use in detectors that will operate in the ultraviolet spectral region; emitters for bright, full-color, flat-panel displays; lasers for ultraviolet spectroscopic uses; and electronics operating in radiation or high-temperature environments. Materials are being pursued primarily in III–V and wide-bandgap II–VI semiconductors, with emphasis on atypical compounds and expansion to the extremes of the periodic table.

Additional efforts continue to explore heterovalent epitaxy that combines, for example, Group II–VI and Group III–V semiconductors into a single system of heterostructures. In addition to enabling unique and promising semiconductors to be grown on available substrates, this further expands the base of semiconductors that can be commingled to yield highly engineered optoelectronic materials. Interest exists in the formation of lateral periodic structures, either from growth on patterned or nonplanar substrates or from self-assembled, modulated solid-phase formations.

Our overall emphasis is to combine materials science with solid-state physics to investigate the fundamental aspects of growth, defects, and physical properties of multilayer semiconductor structures. Opportunities remain to be explored in the areas described above.

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Electromagnetic Materials

Air Force optoelectronic signal processing, communications, surveillance, and optical warfare systems require continual improvements in performance. This research project is directed toward developing advanced optoelectronic materials to provide those required improvements in future Air Force systems, thereby enhancing the effectiveness of tomorrow's warfighters. In particular, we seek to generate the fundamental knowledge and the materials data base required for the growth and use of novel, as well as existing, optoelectronic materials and structures. No single material has the combination of properties required for all applications, so several classes of single-crystal semiconductors—including a variety of heterostructure combinations—are currently under investigation. Similarly, quantum-well semiconductor heterostructures for electro-optical and nonlinear-optical materials are also being studied.

Compound semiconductors and heterostructure combinations of such materials are the foundation of new generations of wavelength-diverse, highly efficient optoelectronics, and highly sensitive, frequency-agile electro-optics. These materials provide the properties necessary for advanced surveillance and reconnaissance applications, and optoelectronic communication systems for a future command and control infrastructure. We are currently investigating compound semiconductors for use in detectors that will operate in the far-infrared spectral range, lasers for infrared spectroscopic uses, and optoelectronics for active countermeasures in the infrared spectrum. Materials are being pursued primarily in III–V semiconductors, with emphasis on atypical compounds and expansion to the extremes of the periodic table.

Efforts continue to explore Group IV semiconductor heterostructure technology based on silicon substrates for next-generation optical sensors, interconnects, and emitters. Emphasis is, again, on atypical compounds such as germanium-carbon and silicon-germanium-carbon. Success in this area will preserve the immense technological investment in silicon electronics while expanding the technology to reap the benefits of optoelectronics. Interface formation, equilibrium and nonequilibrium alloy growth processes, and stability are heterostructure technology issues that are being addressed with both experiments and extensive modeling efforts. Interest exists in the formation of lateral periodic structures from self-assembled, modulated solid-phase formations.

Our overall emphasis is to combine materials science with solid-state physics to investigate the fundamental aspects of growth, defects, and physical properties of multilayer semiconductor structures. This will form the basis of an ability to engineer the energy band structure of semiconductors to achieve high-performance optoelectronic and electro-optical devices. Opportunities remain to be explored in the areas described above.

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Photonic Physics

Photonic physics research explores new ideas, knowledge, and insights in selected aspects of photonics. Ultrafast optoelectronic techniques are being investigated with the hope of dramatically advancing the speeds and available power of electronic circuits. Picosecond and femtosecond optical pulses are being studied to generate very wide band signals, as well as to control and test electronic circuits at frequencies into the millimeter-wave range and into the terrahertz range. Optical interconnect techniques are being investigated for application, especially to millimeter-wave circuit interconnections. Optoelectronic generation of very high power terrahertz pulses are being studied. These could significantly contribute to so-called impulse radar systems. Very wide band, mode-locked semiconductor lasers are being devised and investigated as important devices in their own right, as well as for practical implementations of the ultra-high-speed electronic studies. Semiconductor laser arrays are being intensively investigated in support of ongoing important Air Force development programs. Very low noise and very low threshold semiconductor lasers are being pursued for applications in communications and information processing. Directed energy beams, particularly laser beams, are being explored in a wide variety of direct-write materials-processing techniques that offer broad and extremely important new capabilities, particularly in microelectronics and micromechanics fabrication and packaging.

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Optics

This research emphasizes optically pumped solid-state lasers, nonlinear optics, and a variety of novel optical techniques with the promise of advancing Air Force goals in a wide variety of applications. Nonlinear-optical (NLO) techniques, particularly two-wave and four-wave mixing techniques in photorefractive materials, and four-wave mixing in Kerr media, are being investigated for a variety of novel, potentially important applications, such as optical beam combining and quality enhancement, image amplification, and novelty filtering. Novel NLO materials are also being studied, including the use of resonances in gases. The latter are very attractive because of their capability to produce semiconductor diode lasers that are accurately tuned to the resonances. Gases embedded in "caged" solids are also being reviewed. These materials could offer the benefits of resonances in gases at high pressure, but in solid-state form. Electromagnetically induced transparency is being studied as a means for taking advantage of resonances for nonlinear optics, without the concomitant absorption. Many other novel phenomena related to electromagnetically induced transparency are also potentially useful. Novel, efficient means are being devised to convert the wavelength of existing lasers into new regimes important for applications.

A recently initiated area of emphasis is in infrared sources for countermeasure applications. Of interest are laser and NLO research that could lead to infrared sources; tunable or multiple fixed-frequency, continuous-wave, or high-repetition rates; and (most important) potentially high average power. NLO techniques are being adapted and extended to the millimeter-wave region, principally through the study of nonlinear transmission lines and three-wave mixing, with large effective nonlinearities. New techniques are also being developed in near-field optical microscopy, a field with revolutionary technological possibilities.

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Atomic and Molecular Physics

This program involves experimental and theoretical research on the properties and interactions of atoms and molecules and forms the basic underpinning of a large range of technological applications in navigation, guidance, communications, atmospheric physics, low- and high-altitude nuclear weapons, effects phenomenology, directed-energy weaponry, and lasing mechanisms. Topics to be pursued include the following:

1. Trapping and cooling atoms and ions for high-resolution spectroscopy, studying cold-atom collisions, and developing advanced frequency standards.
2. Studying ultraviolet emission cross sections of atmospheric species by electron impact.
3. Observing interactions of atoms in strong electric, magnetic, and radiation fields.
4. Developing atomic physics fundamental to understanding plasma-enhanced deposition and microetching processes.

5. Understanding antiproton capture, confinement, transport, injection, and annihilation processes.

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Plasma Physics

We are seeking innovative approaches for exploring novel concepts that exploit the collective interactions of charged particles with electromagnetic fields. Our primary areas of interest include basic research on the following topics:

1. Electron-beam-driven sources of high-power microwave and millimeter-wave radiation.
2. Microwave interactions with plasmas.
3. Numerical simulation of plasma phenomena.
4. Plasma processing.
5. Energy-efficient methods to generate and maintain free electron densities of 10(13) per cc in sea-level air.

Other plasma research topics will be considered on a case-by-case basis. However, in general, this program is not interested in dense (strongly coupled) plasmas, fusion plasmas, or space plasmas.

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Imaging Physics

This program investigates fundamental issues in imaging physics with strong user endorsement. These include issues concerning the image formation and propagation processes. Physical and mathematical problems in inversion/reconstruction and inverse scattering, as well as electromagnetic wave generation/propagation in various media, are central to this topic. New ways of representing object fields with a class of basis functions broader than sines and cosines and propagating these fields to distant planes can lead to advances in feature extraction and secure communications. Theoretical foundations for imaging diversity methods (e.g., wavelength diversity, phase diversity, polarization diversity) are of interest.

Multi-hyperspectral techniques, data/sensor fusion, and smart sensors are being investigated. The focus of these three areas is to evaluate the advantages of on-chip and on-sensor processing for space-based and ground-based systems, as well as electronic mimicking of biological vision systems. The goal is to provide real-time information to the battlefield commander rather than raw data. Advances in image compression, integrated hardware and software parallelization, real-time response, and adaptive imaging controllers (e.g., neural networks) are sought for both ground-based and space-based sensing systems. Fundamental research relating to the performance and limitations of large-scale space-based optics are of interest.

Unconventional imaging methods are being developed to provide novel active (artifically illuminated) and passive (naturally illuminated) imaging and target recognition capabilities for war combatants. Initial unconventional imaging methods research will concentrate on synthetic aperture techniques, information recognition and extraction, and multiresolution imaging of and from space-based assets. Theory and techniques of adaptive optics and mathematics to facilitate turbulence/aberration compensation for both active and passive imaging methods are of interest.

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Chemistry and Life Sciences

A wide range of fundamental chemistry and life sciences research is supported to provide the Air Force with novel options to increase performance and operational flexibility. The chemistry effort in the directorate supports the structural materials activities in the Directorate of Aerospace and Materials Sciences to make an integrated AFOSR structural materials program. Although the program descriptions that follow are specific subareas of interest, we are also interested in exploring novel ideas that bridge the disciplines. The interfaces between biology and chemistry, biology and physics, psychology and physics, or biology and behavior often provide the insights necessary for technological advances. We encourage your creativity in suggesting novel scientific approaches for our consideration.

Chemical Reactivity and Synthesis

Through this research, we seek advanced materials and associated processes with low initial cost, long lifetimes, improved performance, and minimal life-cycle impact on the environment. Our three major research areas include (1) the search for safe alternatives to current hazardous materials and processes, (2) investigation of biological/biochemical and biomimetic approaches to aerospace materials design and preparation, and (3) studies of chemistry and materials science related to safe, long-life aircraft coatings.

Current programs investigate materials and processes that are hazardous to the environment or to personnel, with the goal of providing technology for safe alternatives without sacrificing properties or cost. Materials of interest for study include, but are not limited to, fire suppressants and deicing/anti-icing chemicals. We are exploring novel, nonhazardous processes for recovering expensive chemicals from aerospace polymeric material waste. We seek to understand the optimized materials design and process mechanisms in living organisms to incorporate their advantages into materials and processes (e.g., ambient temperature fabrication of tailored optoelectronic materials; lightweight, uncooled infrared sensors). We seek knowledge about controlled preparation of inorganic crystals with ordered structures applicable to electronic or optoelectronic applications. We are also exploring the biology, biochemistry, materials science, and photochemistry of functional biological materials, especially infrared sensors in living organisms, with the goal of understanding the transduction mechanism and creating robust biomimetic analogs.

In a new research initiative, we have begun an integrated study of the chemistry of polymeric aircraft coatings to provide technology with longer life and lower maintenance costs. Included in the scope of this initiative is an exploration of the mechanisms and role of photochemistry, thermochemistry, biochemistry, adhesion chemistry, and solvent attack in environmental degradation of coatings. We are studying novel concepts for polymeric-coatings chemistry related to safe application, selective removal, coloration, and corrosion protection. We are also investigating the role of microbial-induced corrosion processes in structural aluminum and its protective coatings.

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Polymer Chemistry

The goal of this research area is to gain a better understanding of the influence of chemical structures and processing conditions on the properties and behaviors of polymeric and organic materials. This understanding will be important in the development of advanced materials for Air Force applications and the use of these materials in Air Force systems. Our approach is to study the chemistry and physics of these materials through synthesis, processing, and characterization. This area addresses both functional properties and properties pertinent to structural applications. Materials with these properties will be needed in future Air Force systems for achieving global awareness, global mobility, and space operations as envisioned in New World Vistas.

Our current interests include photoactive polymers, electronic properties of polymers, polymer blends, liquid crystals and liquid crystalline polymers, and nanostructures. Proposals with innovative material concepts that will extend our understanding of the structure-property relationship of these materials and achieve significant property improvement over current state-of-the-art knowledge are sought. Research interests include creating new and improved properties, achieving reproducible properties, and addressing durability of properties during the life cycle of Air Force systems.

In the area of photoactive polymers, research will primarily focus on second- and third-order optical nonlinearity and photorefractivity. It is desirable to increase the electro-optical coefficients of organic and polymeric materials with appropriate levels of thermal and temporal stability. Larger resonant and nonresonant third-order optical nonlinearities are desirable. Adjustment in speed and wavelength sensitivity of organic photorefractive polymers is also of interest. Examples of electronic properties of interest include conductivity, electrochromaticity, and electroluminescence. In the area of structural properties, polymers with high thermomechanical properties are desirable. End uses of these structural polymers include aircraft and rocket components, canopies, coatings, and space structures. Issues relating to impact toughness and lifetime durability will be of special interest.

Material concepts that can improve on the above-mentioned optical, electronic, and mechanical properties

of polymers are sought. These concepts include, but are not limited to, polymer blends, liquid crystals and liquid crystalline polymers, and nanostructures.

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Surface Science

Surface science supports basic research in chemistry on the interface, reactivity, and analysis of surfaces and thin films. Our goal is to improve our understanding of surface processes involved in these areas. Research in the chemistry and morphology at interfaces will lead to a better understanding of the mechanisms involved in those surface processes, which in turn will lead to more effective modification and control of surface relationships.

Research in surface chemistry, tribochemistry, electrochemistry, and chemical sensors will study basic chemical phenomena at the interface, such as nucleation and growth of thin films and alloys (not to include semiconductors), friction and wear, lubrication, corrosion and materials degradation, compact power sources, and electrochemically induced reaction products and kinetics. Work supported by this program includes chemical sensing of corrosion and wastes at the interfaces/surfaces of aircraft and their servicing environment. This may lead to development of diagnostic tools that will alert technicians to aircraft areas that may experience corrosion or wastes produced in their service area, thus helping to monitor and prevent these problems. This also includes a program which looks at the mechanism of the corrosion of aluminum alloys and prevention of that corrosion.

Our other work involves the solid, liquid, and vapor states of the tribochemistry program and is designed to provide the Air Force with improved novel lubricants, lubrication systems, and wear-resistant coatings for current- and future-generation aircraft engines. The electrochemistry program is interested in molten salt systems for compact power sources and new alloy systems for a variety of Air Force systems. Finally, the surface chemistry program is interested in thin magnetic and alloy film growth kinetics and mechanisms at the surface to understand structure property relationships for future materials needs.

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Theoretical Chemistry

The objectives of the theoretical chemistry program are to develop and apply predictive tools for designing new materials and improving processes important to the Air Force. Areas of interest include the structure and stability of molecular systems that can be used as advanced propellants; methods to calculate the NLO properties of materials; determining, predicting, and modeling the atomic interactions at interfaces that affect wear and lubrication and that control deposition and growth of nanostructures on surfaces; calculating properties of bulk materials from atomistic considerations; and using theory to describe and predict the details of ion-molecule reactions relevant to ionospheric and space effects on Air Force systems.

Interest in advanced propellants is concentrated in the High Energy Density Matter (HEDM) program (managed jointly with the Phillips Laboratory), which aims to develop new propellant systems to allow double the current payload capacity to be put into orbit. Theoretical chemistry is used to predict promising energetic systems, to assess their stability, and to guide the efficient synthesis of selected candidates. Current emphasis is on identifying novel energetic molecules and investigating the interactions that control or limit the energy that can be stored by energetic dopants in cryogenic solids. We also are seeking to develop theoretical tools that can be used to help guide the synthesis of HEDM candidates. These tools will help identify the most promising synthetic reaction pathways and predict the effects of solvation and other many-body and media effects on synthesis.

Research on metals and ceramic materials emphasizes clusters, nanophase materials, and the structure, stability, and growth of metal/ceramic interfaces. We also encourage the development of new methods and algorithms that take advantage of parallel computing architectures to predict properties with chemical accuracy for systems having a very large number of atoms.

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Molecular Dynamics

The objectives of the molecular dynamics program are to understand, predict, and control the reactivity and flow of energy in molecules. This knowledge will be used in atmospheric chemistry to improve our detection and control of signatures; in high-energy-density material research to develop new energetic materials for propellants and explosives; in chemical laser research to develop new high-energy laser systems; and in many other chemical systems in which predictive capabilities and control of chemical reactivity and energy flow at a detailed molecular level will be of importance.

Areas of interest in atmospheric chemistry include the dynamics of ion-molecule reactions relevant to processes in weakly ionized plasmas in the ionosphere, atmospheric heterogeneous chemistry, gas-surface interactions in space, and reactive and energy transfer processes that

produce and affect radiant emissions in the upper atmosphere. Research on high energy density matter for propulsion applications investigates novel concepts for storing chemical energy in low-molecular-weight systems, the stability of energetic molecular systems, and the storage of energetic species in cryogenic solids. Work on chemical reactivity and energy localization in solids is focused on understanding the processes that control the sensitivity of explosives. Research in energy transfer and energy storage in metastable states of molecules supports our interest in new concepts for chemical lasers.

A new interest is the study of the structure, stability, and growth of metal/ceramic interfaces. Fundamental studies aimed at developing basic understanding and predictive capabilities for chemical reactivity, bonding, and energy transfer processes are also encouraged.

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Chronobiology and Neural Adaptation

This program supports basic research on the circadian timing system—the biology underlying fatigue—including individual differences in performance prediction and the brain processes involved in regulating adaptation to changes in state (i.e., from sleep to waking to arousal). Current experimental approaches include both human and animal behavioral studies, as well as biochemistry (particularly neurochemistry), molecular biology, electrophysiology (including lesion studies), neurophysiology, and pharmacology. Other approaches will certainly be considered.

The focus of the chronobiology portion of the program is to elucidate biological mechanisms responsible for circadian rhythmicity and how these mechanisms influence behavior relevant to skilled human performance. Current efforts are investigating the functional organization of the circadian pacemaker, mechanisms of entrainment, and output processes. Reproductive studies will not be considered.

The neural adaptation portion of the program gives high priority to investigations that rigorously examine the behavioral consequences of biochemical regulation of nervous system function to elucidate functional relationships between brain chemistry and performance.

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Perception and Cognition

This program supports behavioral research on higher order aspects of human information processing that contribute to skilled human performance. The overall objective is quantitative modeling of ways that humans—both as individuals and in small teams—process information to learn, solve problems, and make decisions. Specific objectives include a model of individual attributes to predict levels of individual performance, theory and tools of intelligent tutoring systems to improve technical training, measures of functional communication and skill in teams to automate command and control, and models of visual and auditory perception for improved human/machine interfaces. The study of these topics under high workloads, in training environments, or in team situations is encouraged. Multidisciplinary approaches are also encouraged, especially if used in the development of quantitative models of these human performance issues.

This program offers an opportunity for researchers to use the unique research facilities of Air Force laboratories in collaboration with Air Force Armstrong Laboratory scientists. The following is a list of current areas of interest; in some cases, additional details on facilities can be obtained from the Internet sites indicated.

1. Learning and performance abilities—The focus of this research is on assessing individual differences in cognitive, perceptual, and psychomotor abilities, and the interaction of those abilities with stress, decision making, situation awareness, personality, and motivation. Studies also examine the role of these factors as predictors of performance in training and other complex environments. The Air Force laboratory facilities are uniquely suited to large-scale (hundreds of subjects per week) studies involving a broad sample of the U.S. 18-year-old population.
2. Intelligent tutoring—The focus of this research is on theory-based automated instructional strategies. Air Force facilities offer unique tools for large-scale assessments of pedagogical approaches involving a broad sample of the U.S. 18-year-old population. Additional details can be found at Web site http://xenon.brooks.af.mil/HSC/AL/HR/HRT/HRTI/train.htm.
3. Team performance—The focus of this research is on distributed team decision making and performance in demanding environments. Unique Air Force facilities include a high-fidelity simulator with embedded performance measures that permits comparison of trainees' and experts' AWACS performances on tasks of dynamic resource allocation.
4. Perception—The focus of this research is on visual and auditory tasks associated with the design of novel human interfaces. Unique facilities for vision research include a large field of head-mounted displays and a terrain board for research on attention and pattern recognition. Additional details are available at Web site

http://129.48.133.101. The Air Force facilities for auditory research include an anechoic chamber equipped with hundreds of loudspeakers, spherically arranged, to support research on sound localization and the generation of complex sound fields.

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Sensory Systems

The Sensory Systems Program is a multidisciplinary research program designed to develop a better understanding of dynamic input into human visual, auditory, and vestibular systems. One new area of interest is identifying biological materials that may enhance human visual, auditory, or vestibular system processes. In general, this program supports research on sensing systems of interest to the Air Force, with emphasis in two areas:

1. Research in visual, auditory, and vestibular senses coupled with multisensory and sensorimotor integrative mechanisms—This effort encourages theoretical and experimental approaches involving psychophysics and psychoacoustics. It is encouraged that basic research in these areas be carried out in concert with in-house research efforts at the Armstrong Laboratory located at Brooks Air Force Base, Texas, and Wright-Patterson Air Force Base, Ohio.
2. The ability of a biological material to act as a detector or sensor for the purpose of enhancing human visual, auditory, and vestibular communication processes—This new research area is designed to determine a biological material's fundamental physical properties and how those properties may be incorporated into existing detection devices or act alone. Researchers from the fields of theoretical and experimental biophysics, bioengineering, biology, biochemistry, and physiology, integrated with classical materials science, are encouraged to work in concert with in-house scientists at the Armstrong Laboratory at Brooks Air Force Base, Texas, and the Wright Laboratory at Wright-Patterson Air Force Base, Ohio.

The goal of the Sensory Systems Program is improving our understanding sensing mechanisms to help improve human performance as well as to develop machine sensors with the exquisite sensitivity and specificity of biological sensory systems.

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Bioenvironmental Sciences

Air Force operations use physical and chemical agents that are potentially harmful to Air Force personnel, the surrounding populace, and the environment. These agents include radiant energies (e.g., microwaves, laser light) as well as fuel components, lubricants, solvents, and heavy metals. (A list of chemicals is available on request.) Chemical agents may be found in waste streams on Air Force installations or as contaminating compounds in ground water, soil, and leaky storage containers. To protect humans, maintain safe working environments, and facilitate cleanups of contaminated sites, the Air Force supports basic research in understanding the effects of these chemicals on biological systems, the mechanisms of toxicity, and the ability of microorganisms to degrade and detoxify hazardous compounds. Although the major emphasis of this program is on chemical agents, the program also supports directed fundamental research related to understanding how microwaves and ultrashort laser pulses interact with tissues at the cellular and subcellular levels.

The following represent some research interests of the Air Force in bioenvironmental sciences:

1. Predictive toxicology
   a. Cellular/molecular mechanisms of toxicity
   b. In vitro structure-activity relationships and their quantitative, computational, and predictive implications
   c. Biological markers of toxicity and metabolism
   d. Physiologically based pharmacokinetic modeling of toxic Air Force chemicals
2. Biodegradation
   a. Novel microbial metabolic pathways (anaerobic and aerobic) and the removal/degradation of metals and chemicals, including energetic nitrogen-containing compounds
   b. Modification of metabolic pathways, cometabolism, and enhanced biodegradation
   c. Improved biodegradation techniques via gene manipulation
   d. Role of biotic interrelationships in optimizing degradative potential
3. Bioeffects of subnanosecond laser light and microwaves
   a. Toxic effects on structural and functional components of the cell
   b. Radiation-induced alterations in genetic apparatus and cellular biochemistry

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Mathematics and Geosciences

The Directorate of Mathematics and Geosciences is responsible for basic research in mathematical and computer sciences and geosciences in the areas described in this section. Many critical research activities are multidisciplinary and involve support from the other scientific directorates within AFOSR. Such activities include joint research with the Directorate of Physics and Electronics into the design of high-power microwave devices and joint research with the Directorate of Chemistry and Life Sciences in intelligent tutoring. The control theory and mathematical modeling research supported by this directorate complements many structural, fluid mechanics, and propulsion research programs supported by the Directorate of Aerospace and Materials Sciences. This directorate also participates in the JSEP (see the introduction to the Physics and Electronics section for details).

Dynamics and Control

This program is devoted to basic research in dynamics and control, leading to improved techniques for the design and analysis of control systems with enhanced capabilities and performance for use in future Air Force missions. Proposals should be linked to appropriate Air Force applications, which currently include the development of robust feedback controllers for advanced high-performance aircraft and adaptive, reconfigurable flight control systems; control sensors and actuators; control of fluid flow processes associated with aerospace vehicles; the control of low-signature, tailless, combat aircraft and the control of electromagnetic radiation by mastering the properties of a propagating surface; control and optimal design issues in aeroengines; imaged tracking and robust feedback control in high scintillation environments; control of autonomous aerial vehicle systems; and novel hybrid control systems that can intelligently manage actuator, sensor, and processor communications in complex systems. We emphasize research in distributed-parameter control (including control of complex coupled fluid-structure systems); robust, adaptive multivariable feedback control for both linear and nonlinear systems; multidisciplinary design optimization; and, to a lesser degree, fundamental applied research in stochastic control, control of discrete event dynamical systems, and use of neural networks for control design.

Research in robust multivariable feedback control will develop mathematical methods that allow the design and analysis of feedback systems that achieve stability and satisfy other performance objectives in the face of model uncertainties. There is increased interest in the development of a theory of robust control for nonlinear and distributed-parameter systems, as well as in novel approaches to effective robust-control-oriented system identification techniques. Support for research in linear systems theory is decreasing.

Distributed-parameter control problems involve systems with dynamics given by partial differential equations, integrodifferential equations, or equations with delays. New integrated approaches are needed to develop approximation techniques for the identification, control, and optimization of distributed-parameter systems. Although efforts continue at a decreased level in dynamics and control theory for flexible structures, increased attention is focused on mathematical techniques that support the development of modern theory applicable to controlling fluid flow and combustion processes as well as complex, highly nonlinear coupled interactions between structural deformation and unsteady flows. These research efforts are coordinated with ongoing efforts in aerospace engineering that emphasize experimental research.

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Physical Mathematics and Applied Analysis

This program pursues mathematical models and their analysis in areas of interest to the Air Force. Our goal is to distill focused mathematical models of particular physical phenomena and the mathematical methods for their analysis, as well as to produce models sufficient for numerical computation. The payoffs include understanding and modeling physical phenomena (e.g., nonlinear optics, turbulent flow) leading to methods for their simulation and control.

Although it supports a broad range of topics, this program concentrates on several special interests: nonlinear optics, inverse problems (the radar interpretation problem and nondestructive evaluation), mathematical materials science, and theoretical fluid mechanics (particularly transonics and hypersonics). All of these areas have in common the nonlinearity of their mathematical descriptions. Nonlinear mathematics exhibits a spectrum of behavior for which effective mathematical understanding is either unavailable or only beginning to emerge. What is striking is the ubiquitous appearance of coherent structures (solitons and their relatives), chaotic solutions, or formation of singularities in many seemingly disparate physical scenarios. Research emphasizes both analytical and numerical tools in tackling these problems.

One goal of nonlinear optics is the effective exploitation of lasers. Solitons, chaos, and other operational possibilities that affect beam control, imaging, and diode array stability are stressed.

Recent work in mathematical materials science involves a blend of nonconvex energy integrands and modern variational approaches that attempt to incorporate measure theory and homogenization in a computationally useful way. It is anticipated that insight into the design of

smart skins and exotic composites would be furthered by such research.

The inverse-problems area seeks to deduce the nature of the scatterer from the waves it scatters back to the observer. The emphasis here is to confront scenarios in which the Born approximation and its obvious extensions are inapplicable. Another area of interest here is image enhancement for the purposes of scene analysis and target acquisition.

Research in fluid mechanics could seek to include real gas effects and rarefied flow regimes as well as stores separation in transonic flight. Nonlinear stability, important distinguished limits, and clarification of unresolved issues in noncontinuum models are other areas of interest.

Research in the mathematics of combustion/detonation is expected to increase modestly.

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Computational Mathematics

This program aims to develop improved mathematical methods and algorithms that exploit advanced computational capabilities in support of Air Force scientific computing interests. For the most part, this program seeks to develop innovative methods and algorithms that improve modeling and simulation capabilities. These improved capabilities, in turn, enable understanding, prediction, and control of complex physical phenomena crucial to the Air Force. These phenomena include fluid mechanics, combustion processes, structural dynamics, high-cycle fatigue in turbine engines, control of large flexible structures, HEDMs, crystal growth, processing and performance of composite and tailored materials, weather modeling, plasma dynamics, and electromagnetic pulse generation. Research in the Computational Mathematics Program enables technological advances in structural integrity, airbreathing propulsion, rocket and space propulsion, aerodynamics and hypersonics, and high-power microwaves. Our research also supports the national agenda in high-performance computing.

We are developing numerical methods and algorithms to exploit fully the potential of parallel computing for fast, accurate numerical solutions of complex systems occurring in both the engineering design of Air Force systems and their operation. Efficient use of available parallel machines requires that we pay increased attention to dynamic resource allocation and load balancing, domain decomposition techniques, scalable parallel algorithms, adaptive meshing for shock tracking, and parallel schemes for adaptive grid generation. As the cost of hardware continues to decrease, the results of this program may affect the design of specialized architectures for solving critical scientific problems.

Typically, the computational models in this program rely on some numerical scheme that implements a discretization of continuum mechanics equations—generally partial differential equations—that represent the physics of the situation. However, alternative computational models may be appropriate for many problems. To characterize the behavior of large, complex, real-world systems, we are examining modeling approaches that enable efficient, robust multidisciplinary design analysis and optimization. Overall, we are investigating both traditional and radical approaches in this program. We are developing and improving a variety of numerical methods in this subarea, including homogenization techniques, continuation methods, finite elements, particle and vortex methods, finite difference methods, essentially nonoscillatory methods, and spectral methods. In addition, fast, accurate, and robust methods for solving large systems of linear equations lie at the heart of many scientific computing problems of interest to the Air Force. For this reason, computational linear algebra, especially multilevel or multigrid techniques, continues to receive attention. This emphasis, however, is diminishing.

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Optimization and Discrete Mathematics

Our goal is to develop mathematical methods for solving large or complex problems, such as those occurring in logistics, engineering design, and strategic planning. These problems can often be formulated as mathematical programs. Therefore, research is directed at new linear and nonlinear programming methods, especially when formulated for the solution of selected Air Force problems. We are also emphasizing discrete structures, as they often represent important Air Force problems.

Three areas of particular importance are emphasized in discrete mathematics. First is the optimal solution of integer programming models and other combinatorially based structures. These structures arise in areas of interest to the Air Force, such as the design of very large-scale integrated networks, frequency assignment, and scheduling and routing. Second, in addition to the evolution of traditional solution methods, the program supports new algorithmic paradigms (e.g., simulated annealing, genetic algorithms). Third, we support research in discrete event systems, especially as it relates to Air Force transportation, manufacturing, and command and control systems.

Research in optimization focuses on the development of special algorithms for the particular structures that arise. Because networks are so important for military logistics problems, optimization over networks is a major

component of our program. Research on stochastic optimization, which will benefit from increased parallelism, and on the use of nonlinear programming for the optimization of polymers and biomolecules, will be undertaken. In cases where exact optimization is impossible, we are interested in innovative combinations of artificial intelligence and operations research.

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Signal Processing, Probability, and Statistics

This research activity is concerned with the systematic analysis and interpretation of data. Signals (communications) and image (for surveillance) data are of special importance. Signals are physically generated, propagated through electromagnetic or other media, and recaptured for use through different mechanisms. Modern radar, infrared, and electro-optical sensing systems produce large quantities of raw signaling that exhibit hidden correlations, are vulnerable to distortion by noise, and retain features tied to a particular physical origin. Statistical research that treats spatial and temporal dependencies in such data is necessary to exploit the usable information within.

Among the outstanding problems and issues in signal processing is the need to develop resilient algorithms for data representation in fewer bits (compression), image reconstruction/enhancement, and spectral/frequency estimation in the presence of extraneous corrupting factors. These factors can involve deliberate interference, noise, ground clutter, and multipath effects. We maintain involvement with sophisticated mathematical methods—including time-frequency analysis and generalizations of the Fourier and wavelet transforms—that deal effectively with the degradation of signaling transmission across a channel. These methods hold promise in the detection and recognition of characteristic transient features, the synthesis of hard-to-intercept communications links, and the achievement of faithful compression and fast reconstruction for audio and video data.

The Air Force has a responsibility to interpret and use data in the logistics and human resource management arena. The methods of probability modeling have proven effective in upgrading the performance of both human and automated systems. However, it will be necessary to achieve even greater facility with these models for the design of better systems architectures and the testing and evaluating of new systems. We emphasize those probabilistic methods in which prior information can be meaningfully integrated into the performance-monitoring process, with a view toward achieving an optimal degree of situation awareness as well as reactive capability during combat.

With an ever-improving repertoire of tools from modern signal processing and statistical science, the Air Force will maintain its lead in communications flexibility, command an encompassing scope in reconnaissance, and project air power through efficient and responsive systems, all at a manageable cost.

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Software and Systems

The goal of this research effort is to develop advanced computing and networking capabilities to support future Air Force information needs, especially in command, control, communications, and intelligence (C3I) systems. To this end, this program has two principal emphases: (1) formal approaches to complex computer system design, and (2) research that advances the development of high-speed, highly available command and control networks.

We seek mathematical approaches for the specification, design, and analysis of distributed systems. Formal mathematical methods, especially those that involve aspects of timing, control, dependability, and security, will be crucial to development of critical Air Force computer systems. Design methodologies that take into account the complexities of the external environment in which computers operate are especially important. We are also interested in approaches to the specification and design of new paradigms for distributed computing (e.g., agent technology).

Highly available command and control networks will have the following requirements: (1) reconfigurability and flexibility that allow for insertion of rapidly developing network technology, (2) interoperability and high quality of service for an increasingly diverse set of processors and data links, (3) protection mechanisms to ensure the integrity of information flowing across the network, and (4) the ability to "gracefully degrade" under adverse conditions, providing a minimal level of performance for essential network services. To provide for reconfigurability and interoperability, research is needed in systems modeling techniques and abstractions that help in the design and analysis of open-ended, heterogeneous, distributed systems. For network protection, researchers will focus on determining and analyzing network security properties at all network layers and examining how to ensure that a network possesses these properties. Also of interest are modeling and analysis techniques that help in the design of systems that gracefully degrade and innovative protocols that facilitate graceful degradation of network resources.

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Artificial Intelligence

The timely management of information, and the ability to make decisions based on that information, are of paramount importance within this program. The key issue that we are addressing is how to effectively incorporate all available information, from diverse sources and modalities, into the decision process. To understand this issue, we are sponsoring research into ways to make the best use of uncertain information; share and disseminate information; increase the accuracy, speed, and economy of the recognition and identification process; and aid the intelligence analyst.

The program concentrates on research needed to develop large-scale intelligent systems that can address practical Air Force needs. To that end, we seek means to scale up those methods that work for small knowledge-based systems. We need to overcome present limitations in the amount of knowledge used because of knowledge acquisition and management deficiencies. Present limitations on meaningful systems adaptation and improvement with use also need to be overcome. Formalisms need to be developed for the representation of and reasoning with uncertainty, handling corrupt information, and effectively using experiences.

To aid the information analyst in fusing information from diverse modalitities, we seek means to combine numeric and symbolic inference methods. Research could also focus on integrating probabilistic reasoning methods with traditional formal logic methods, and perhaps with other forms of computation. Qualitative methods that will drastically simplify computation and increase performance robustness are also of interest.

We are seeking to develop technology that will support decision making. To that end, research is needed to develop intelligent agents capable of gathering information, reducing data to a manageable amount of essential information, and cooperating with other agents to solve problems. Research is also needed to combine artificial intelligence methods with operations research tools to overcome inefficiencies in solving some mission-critical Air Force problems (e.g., scheduling in a distributed, dynamic environment).

The vision- and image-understanding research within this program concentrates on solving those problems that interfere with the building of robust, accurate, and timely recognition systems. Research is directed toward the development of context-based image data bases needed by the Air Force for time-critical and resource-bound operating conditions. The research is also directed toward applications such as surveillance, object recognition, target identification, cartography, scene interpretation from image streams, and the fusion of multisensor inputs. Research in object and scene interpretation from sensors using the visual, infrared, and radio frequency bands of the electromagnetic spectrum includes context-based, geometric model-based, deformable model-based, and physics-based approaches and the application of theories of invariants.

Intelligent tutoring is an area of increased interest to the Air Force. The focus of this effort is to develop efficient computer-mediated tools for instructional delivery both for training and tutoring, with the objective of reducing personnel needs and optimizing tutoring and training. Adaptive teaching systems that model the trainee and attempt to understand his or her responses by simulating these models is one area supported within this program. Research tasks in intelligent tutoring are linked to the Human Resource Laboratory of the Air Force Armstrong Laboratory, where the evaluation and experimentation with actual trainees occurs.

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Electromagnetics

One emphasis of this program is the development of state-of-the-art antenna systems for communications and radar. Basic electromagnetic radiator research focuses on improvements in efficiency, radiation pattern control, effective bandwidth, impedance matching, and approaches for the control of adaptive phased arrays (both periodically and nonperiodically spaced configurations). Scattering research seeks to characterize and exploit the details of both targets and terrain, together with predicting propagation through dispersive and random media and the use of three-dimensional algorithms for scattering by large objects. Our research also includes high-power microwave (HPM) sources, both narrow and broad band, together with HPM effects on circuitry.

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E-mail: arje.nachman@afosr.af.mil

Meteorology

A fundamental understanding of the physics underlying meteorology is essential for improving the Air Force's capability to support tactical and strategic military readiness.

We are interested in innovative research proposals that seek to illuminate the dynamic distribution of energy among large, medium, and small scales of atmospheric motion, and the nature of relationships between cloud

processes and large motion scales. Although we recognize that measurements and measurement techniques are important in research, we place a higher priority on efforts to extract the underlying physics than on proposals that concentrate on gathering data.

We assign highest priority to research ideas in mesoscale dynamics and predictions, physics and dynamics of precipitation systems, cloud microphysics, boundary layer dynamics, atmospheric electricity, and satellite and radar meteorology, including the development of new remote measurement techniques and analytical techniques for extracting meteorological data.

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Upper Atmosphere

Our research goal is to define the physical and chemical properties of the Earth's middle and upper atmosphere and to determine effects of these properties on Air Force systems operating in or through these regions.

Our main interest is understanding the structure and chemistry of the mesosphere and thermosphere and the physics and dynamics of the ionospheric region. This effort includes modeling atmospheric tides, solar radiation, high-energy particles, magnetospheric disturbances and their impacts on ionospheric dynamics, electron density structure, and optical/infrared radiance structure.

Although we recognize that measurements and measurement techniques play an important role in this area, we are convinced that significant progress will require programs that carefully combine theory with experiment. Thus we emphasize analyzing information to extract the fundamental physics rather than gathering data. We place the highest priorities on research in ionospheric disturbances, ionospheric physics, plasma turbulence and dynamics, ionospheric-magnetospheric coupling, atmospheric transmission and absorption, natural airflow, auroral backgrounds, and upper atmospheric discharge phenomena. Other topics include remote sensing of upper atmospheric properties, theoretical studies of molecular parameters, and coherence effects in spectroscopy.

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Space Sciences

The effects of electromagnetic radiation, charged atomic particles, and electric and magnetic fields can endanger the mission and degrade the performance of Air Force systems operating in near-Earth space. Both the ambient and the disturbed space environment can disrupt the detection and tracking of missiles and satellites, distort communications, and interfere with surveillance operations.

This research provides basic knowledge of the space environment for the design and calibration of Air Force systems operating in and through space. Experimental and theoretical methods are used to study the following:

1. Solar activity.
2. Solar outbursts and their travel from the Sun to the Earth.
3. The particle and field composition of the space environment, especially the Earth's magnetosphere.
4. Changes in this environment caused by natural and artificial disturbances.
5. The response of spacecraft systems and operations to conditions in space.

Current topics of interest include the following:

1. Developing a capability to forecast solar activity—for example, by identifying phenomena on the Sun and in interplanetary space that are associated with perturbations of the aerospace environment.
2. Investigating the production and transport of magnetospheric plasma to understand geomagnetic storm phenomena and to predict the expected charged-particle distributions encountered by Air Force spacecraft.
3. Developing models to simulate wave modes generated during injection of artificial beams into space plasmas.

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IV

Researcher Assistance Programs

The Directorate of Academic and International Affairs sponsors researcher assistance programs that stimulate scientific and engineering education and increase the interaction between the broader research community and Air Force laboratories. Applications for these programs do not always require proposals but generally have specific deadlines, formats, and qualifications, which are shown with each program discussed. ***Researchers applying for these programs should contact the offices listed in each program description.***

United States Air Force/National Research Council-Resident Research Associateship (USAF/NRC-RRA) Program

The USAF/NRC-RRA Program offers postdoctoral and senior scientists and engineers opportunities to perform research at sponsoring Air Force laboratories. The objectives of the program are (1) to provide researchers of unusual promise and ability opportunities to solve problems, largely of their own choice, that are compatible with the interests of the hosting laboratories; and (2) to contribute to the overall efforts of the Air Force laboratories.

Postdoctoral Research Associateships are awarded to U.S. citizens and permanent residents who have held doctorates for less than 5 years at the time of application. They are made initially for 1 year and may be renewed for a second year. A small number of associateships may be available for foreign citizens if laboratory funds are available.

Senior Research Associateships are awarded to individuals who have held doctorates for more than 5 years, have significant research experience, and are recognized internationally as experts in their specialized fields, as evidenced by numerous publications in reviewed journals, invited presentations, authorship of books or book chapters, and professional society awards of international stature. Although awards to senior associates are usually for 1 year, awards for periods of 3 months or longer will be considered. U.S. citizenship is not a requirement.

Associates receive a stipend from the NRC while carrying out their proposed research. The 1996 annual stipend for a regular associate is $39,000, with additional increments for each year past the Ph.D. An appropriately higher stipend is offered to senior associates.

Awardees also receive a relocation reimbursement and may be supported with limited funds for professional travel. Funding is normally provided for approximately 50 associates each year.

For additional information, contact—

Associateship Programs (TJ-2094)
National Research Council
2101 Constitution Avenue, NW
Washington, DC 20418
(202) 334–2760

or

AFOSR/NI
(202) 767–4969, DSN: 297–4969
FAX: (202) 767–5012

University Resident Research Program (URRP)

The URRP enables highly qualified university faculty members to spend 1 year, or 2 years with an extension, at Air Force laboratories working on research problems of interest to the Air Force. Through this program, faculty members can use their expertise to contribute fresh ideas to Air Force research. Air Force Office of Scientific Research (AFOSR) funds and manages the program. Air Force laboratories furnish the necessary support services, facilities, and equipment for the research. This program is limited to U.S. citizens.

Assignments are for 1 year unless the needs of the Air Force require an extension. The Air Force, the faculty member, and the university must agree to the extension, which will not exceed 1 year.

Participants continue to receive salaries from their universities. AFOSR and the Air Force laboratories negotiate with the university for travel and moving expenses and the amount of the salary needed to cover the time of the sabbatical or leave of absence. AFOSR provides the funds to the Air Force laboratory at which the research is done. The laboratory then reimburses the university for the assignee's salary and for the university's contribution to basic fringe benefits, such as health and life insurance, retirement, and Social Security. Cost sharing on the part of the university is encouraged.

An endorsement from the laboratory's chief scientist is required before a candidate's application can be reviewed at AFOSR. Appointees have the status of visiting scientists or engineers in the laboratory and are subject to the general conditions of the laboratory. The date on which appointments begin, which may be any time during the year, is negotiated with the appointees.

For more information, contact—

URRP
AFOSR/NI
(202) 767–4969, DSN: 297–4969
FAX: (202) 767–5012

Summer Faculty Research Program (SFRP)

The SFRP provides research opportunities for qualified faculty members of U.S. colleges and universities at Air Force research facilities within the continental United States. The objectives of SFRP are to:

1. Develop the basis for continuing research of interest to the Air Force at the faculty member's institution
2. Stimulate continuing relations among faculty members and their professional peers in the Air Force
3. Enhance the research interests and capabilities of educators in scientific/engineering areas of interest to the Air Force

University faculty members spend 8–12 weeks during the summer working at an Air Force facility. To qualify, applicants must

1. Be U.S. citizens or permanent residents
2. Be faculty members of accredited U.S. colleges, universities, or technical institutes
3. Have at least 2 years of teaching and/or research experience

After completing this program, participants may submit a proposal for continuing research at their own facilities. Selected proposals are funded under the Summer Research Extension Program (SREP). For regular summer appointments, the research is conducted for a continuous period of 8 to 12 weeks between May 15 and September 30; the start date is flexible.

For the research period, a Fellow receives $740 a week. An expense and travel allowance of about $50 per day to cover the cost of traveling to and from the Air Force research site is available if the Fellow lives more than 50 miles from the research site. AFOSR Fellows may visit the sites before the research period by writing the facility representative ahead of time.

For more information, contact—

Research and Development Laboratories
5800 Uplander Way
Culver City, CA 90230-6608
(800) 677–1363 or (310) 410–1244

or

Summer Programs Manager
AFOSR/NI
(202) 767–4969, DSN: 297–4969
FAX: (202) 767–5012

Summer Research Extension Program (SREP)

After completing the SFRP, participants may submit proposals to continue the research at their universities. These proposals, if accepted, are funded under the SREP. To compete for the SREP award, SFRP participants must submit a complete proposal and proposed budget either during or promptly after their SFRP appointment.

Each proposal is evaluated for technical excellence, with special emphasis on relevance to continuation of the SFRP effort as determined by the Air Force laboratory or center.

The maximum award under the SREP is $25,000, plus the amount shared by the employing institution. Employing institutions are encouraged to share costs because the SREP is designed to initiate research only. The total available funds limit the number of awards.

Proposal deadline is November 1. Funded projects start no earlier than September 1 and end no later than December 15 of the following year.

For more information, contact—

Research and Development Laboratories
5800 Uplander Way
Culver City, CA 90230-6608
(800) 677–1363 or (310) 410–1244

or

Summer Programs Manager
AFOSR/NI
(202) 767–4969, DSN: 297–4969
FAX: (202) 767–5012

Graduate Student Research Program (GSRP)

GSRP is an adjunct effort of the SFRP. The program provides research funds for selected graduate students to work at appropriate Air Force facilities with supervising professors who hold an SFRP appointment or with designated laboratory researchers. The objectives of GSRP are to

1. Provide a productive means for a graduate student to participate in research under the direction of a faculty member or researcher at an Air Force laboratory
2. Stimulate continuing professional association among graduate students, their supervising professors, and professional peers in the Air Force
3. Expose graduate students to potential thesis topics in areas of interest to the Air Force

To qualify as a graduate researcher in GSRP, applicants must be

1. U.S. citizens
2. Holders of either a B.S. or an M.S. degree in the appropriate technical specialty
3. Registered in a graduate school program working toward an appropriate graduate degree at their respective institutions
4. Willing to pursue their summer research work under the direction of a supervising professor who holds an appointment under the SFRP or under a designated Air Force laboratory researcher

The research is conducted for a continuous period of 8 to 12 weeks between April 1 and September 30. The student's research period should coincide with the appointment time of the supervising professor.

A selectee receives a predetermined stipend based on educational level. Holders of a B.S. degree receive about $391 per week; holders of an M.S. degree receive about $455 per week. In addition, a daily expense allowance of about $37 is paid if the researcher lives more than 50 miles from the Air Force research location.

For more information, contact—

Research and Development Laboratories
Summer Research Program Officer
5800 Uplander Way
Culver City, CA 90230-6608
(800) 677–1363 or (310) 410–1244

or

Summer Programs Manager
AFOSR/NI
(202) 767–4969, DSN: 297–4969
FAX: (202) 767–5012

National Defense Science and Engineering Graduate (NDSEG) Fellowship Program

The NDSEG Fellowship Program is a Department of Defense (DOD) fellowship program sponsored by AFOSR, the Army Research Office, the Office of Naval Research, and the Advanced Research Projects Agency. The DOD selects about 100 Fellows per year; the Air Force sponsors about 25 of those Fellows.

AFOSR has a goal of awarding 10 percent of these fellowships to applicants who are members of an ethnic minority group underrepresented in the advanced levels of the U.S. science and engineering personnel pool (i.e., Native American, black, Hispanic, Native Alaskan [Eskimo, Aleut], or Native Pacific Islander [Polynesian or Micronesian]).

These fellowships are for study and research in areas of interest to the Air Force. Fellowships are limited to U.S. citizens who have received their B.S. degrees. Air Force graduate fellowships are tenable at any U.S. institution of higher education offering a Ph.D. in science or engineering.

Students receive stipends of $16,500 the first year, $17,500 the second year, and $18,500 the third year. Stipends are prorated for fellowship periods of less than 12 months; however, the duration of the fellowship will not be less than 9 months. In addition to the stipend, the Air Force pays the student's tuition and provides $2,000 per year to the student's department.

Those Fellows selected and sponsored by the Air Force will be offered the opportunity to become associated with an Air Force laboratory, but they are not required to spend a summer at an Air Force laboratory.

For more information, contact—

NDSEG Fellowships
AFOSR/NI
(202) 767–4969, DSN: 297–4969
FAX: (202) 767–5012

V

Proposal Guidance

The Air Force Office of Scientific Research (AFOSR) invites proposals for basic research in support of the Air Force Defense Research Sciences Program. Proposers selected for funding may be awarded grants, cooperative agreements, or contracts. The areas of interest are covered in Sections II and III of this pamphlet. Application procedures *for a researcher to apply* for programs noted in Section III are specific to each program. Information and proposal procedures can be requested from the office noted in each program description.

Our overriding purpose in supporting this research is to advance the state of the art in areas related to the technical problems the Air Force encounters in developing and maintaining a superior Air Force; lowering the cost and improving the performance, maintainability, and supportability of Air Force weapon systems; and creating and preventing technological surprise.

Proposals under this Broad Agency Announcement (BAA) can be submitted only to AFOSR, be evaluated through a peer or scientific review process, and be selected for award on a competitive basis according to Public Law 98–369, Competition in Contracting Act of 1984, and 10 United States Code 2361. The two primary evaluation criteria, of equal importance, are as follows:

1. The scientific and technical merits of the proposed research.
2. The potential contributions of the proposed research to the mission of the Air Force.

Other evaluation criteria used in the technical reviews, which are of lesser importance than the primary criteria and of equal importance to each other, are as follows:

1. The likelihood of the proposed effort to develop new research capabilities and broaden the research base in support of national defense.
2. The proposer's, principal investigator's, team leader's, or key personnel's qualifications, capabilities, related experience, facilities, or techniques or a combination of these factors that is integral to achieving Air Force objectives.
3. The proposer's and associated personnel's record of past performance.
4. The realism and reasonableness of proposed costs and availability of funds. Although not a primary evaluation factor, price is a substantial factor in the selection of proposals for award.

No further evaluation criteria will be used in source selection. The technical and cost information will be analyzed simultaneously during the evaluation process.

Proposals may be submitted for one or more of the topics in Sections II and III or for a specific portion of one topic. A proposer may submit separate proposals on different topics or different proposals on the same topic. The Government does not guarantee an award in each topic area.

The cost of preparing proposals in response to this announcement is not considered an allowable direct charge to any award made under this BAA or to any other award. It may, however, be an allowable expense to the normal bid and proposal indirect cost specified in the Federal Acquisition Regulation (FAR) 31.205–18 or Office of Management and Budget Circular A-21 or A-122. Only contracting officers are legally authorized to commit the Government to an award under this BAA.

Technology sharing and transfer is encouraged; in this respect, AFOSR welcomes proposals that envision university-industry cooperation. Nonindustry proposers are encouraged to specify in their proposals their interactions with industry and Air Force laboratories, including specific points of contact. Cooperation with or use of facilities in an Air Force laboratory is also encouraged. Personnel interaction (e.g., university faculty or students performing research at industry or Air Force laboratory sites; industry or Air Force staff working in university laboratories) is viewed as highly desirable.

Every effort will be made to protect the confidentiality of the proposal and any evaluations. The proposer must mark the proposal with a protective legend in accordance with FAR 52.215-12 (modified to permit release to outside evaluators retained by AFOSR) if protection is desired for proprietary or confidential information.

Proposals should briefly address whether the intended research will result in environmental impacts outside the laboratory, and how the proposer will ensure compliance with environmental statutes and regulations.

It is Air Force policy to eliminate the use of Class I Ozone Depleting Chemicals (ODCs) in all Air Force procurements. This policy implements Section 326 of the fiscal year 1993 Defense Authorization Act (Public Law 102-484). Unless a specific waiver has been authorized, Air Force procurements (1) may not include any specification, standard, drawing, or other document that requires the use of a Class I ODC in the design, manufacture, test, operation, or maintenance of any system, subsystem, item, component, or process; and (2) may not include any specification, standard, drawing, or other document that establishes a requirement that can be met only by use of a Class I ODC. For the purpose of this policy, the following are Class I ODC's: (1) halons: 1011, 1202, 1211, and 2402; (2) chlorofluorocarbons (CFCs): CFC-11, CFC-12, CFC-13, CFC-111, CFC-112, CFC-113, CFC-114, CFC-115, CFC-211, CFC-212, CFC-213, CFC-214, CFC-215, CFC-216, and CFC-217; and (3) other controlled substances: carbon tetrachloride, methyl chloroform, and methyl bromide. Proposals submitted in response to this BAA will be reviewed by the Air Force with regard to this policy. Where considered essential, specific authorization will be obtained for the use of these substances; these authorized uses will be identified in the resulting contract. Proposers are requested to notify the Air Force if any

Class I ODC will be required in the performance of any contract awarded under this BAA.

Unnecessarily elaborate brochures or presentations beyond those sufficient to present a complete and effective proposal are not desired. Proposals must be submitted as hard copy.

For additional guidance on the form and content of proposals, proposers should refer to the *AFOSR Proposer's Guide* (AFOSR Pamphlet 64-11), which can be obtained by sending a self-addressed label with the request to—

AFOSR/XPC
110 Duncan Avenue, Room B115
Bolling AFB, DC 20332-8080

These pamphlets may also be downloaded from the Federal Information Exchange (FEDIX), an on-line information system accessible via computer and modem. Call the FEDIX computer at (800) 783–3349 (eight data bits, one stop bit, no parity). There is no charge for accessing the information. The FEDIX help line is available at (301) 975–0103 from 8:30 a.m. until 5:00 p.m. EST. FEDIX is also accessible via Internet at the following Telnet address: "fedix.fie.com." At login, type "fedix" or Telnet to "192.111.228.33," or to Web server http://www.afosr.af.mil. To access the National Technology Transfer Center, FTP to "iron.nttc.edu." At login, type "anonymous," and use your e-mail address for the password.

Proposals may be submitted at any time to the appropriate AFOSR program manager or directorate (addresses are found in Section VI). There will be no further solicitations. Historically black colleges and universities (HBCUs) and minority institutions (MIs) are encouraged to apply; however, no portion of this announcement is set aside for HBCU and MI participation. In case of difficulties in determining the appropriate AFOSR addressee, proposals may be submitted to:

AFOSR/PKC
110 Duncan Avenue, Room B115
Bolling AFB, DC 20332-8080

This announcement is AFOSR BAA 97-1 and supersedes the AFOSR Pamphlet 64-1 of 1 October 1995, Research Interest Brochure and BAA 96-1 of AFOSR. This announcement is open ended until revised and should be referenced on all responses.

VI

Directory

Organizational Directory

ORGANIZATION	ADDRESS	NAME AND TELEPHONE NUMBER
Air Force Office of Scientific Research (AFOSR)	AFOSR 110 Duncan Avenue, Room B115 Bolling AFB, DC 20332–8080	Janni, Joseph F., Dr., Director (202) 767–5017; DSN: 297–5017 FAX: (202) 767–6213 Herklotz, Robert L., Col, Deputy Director (202) 767–4929; DSN: 297–4929; FAX: (202) 767–6213
Directorate of Contracts	AFOSR/PK	Hawkins, Edwin C., Mr., Director (202) 767–4945; DSN: 297–4945; FAX: (202) 404–7951
Directorate of Aerospace and Materials Sciences	AFOSR/NA	Chang, Jim C. I., Dr., Director (202) 767–0467; DSN: 297–0467; FAX: (202) 767–4988
Directorate of Physics and Electronics	AFOSR/NE	Wittmann, Horst R., Dr., Director (202) 767–4984; DSN: 297–4984; FAX: (202) 767–4986
Directorate of Chemistry and Life Sciences	AFOSR/NL	Berry, William O., Dr., Director (202) 767–4278; DSN: 297–4278; FAX: (202) 404–7475
Directorate of Mathematics and Geosciences	AFOSR/NM	Holland, Charles J., Dr., Director (202) 767–7899; DSN: 297–7899; FAX: (202) 404–7496
Directorate of Academic and International Affairs	AFOSR/NI	Cerveny, Jan, Col, Director (202) 767–4969; DSN: 297–4969; FAX: (202) 767–5012
European Office of Aerospace Research and Development (EOARD)	EOARD/CC 223/231 Old Marylebone Rd. London NW1 5TH United Kingdom or EOARD/CC PSC 802, Box 14 FPO-AE 09499–0200	Pletcher, John H., Jr., Col, Commander (011) 44–171–514–4950; DSN: 315–235–4950; FAX: (011) 44–171–514–4960
Asian Office of Aerospace Research and Development (AOARD)	AOARD Unit 45002 APO AP 96337–0007	Fujishiro, Shiro, Dr., Director (011) 81–3–5410–4409; DSN: 315–220–4409; FAX: (011) 81–3–5410–4407
Armstrong Laboratory	AL/CA 2509 Kennedy Circle Brooks AFB, TX 78235–5118	Burton, Russell, R., Dr. Chief Scientist (210) 536–3656; DSN: 240–3656; FAX: (210) 536–2371
Aerospace Medicine Directorate	AL/AO-CA 2510 Kennedy Circle, Suite 117 Brooks AFB, TX 78235–5119	Goddard, Glenn, Lt Col, Chief Scientist (210) 536–4751; DSN: 240–2994; FAX: (210) 536–4103
Crew Systems Directorate	AL/CF-CA 2509 Kennedy Circle Brooks AFB, TX 78235–5118	Vacant, Chief Scientist (210) 536–2446; DSN: 240–2446; FAX: (210) 536–2371
Human Resources Directorate	AL/HR-CA 7909 Lindbergh Drive Brooks AFB, TX 78235–5352	Alley, William E., Dr., Chief Scientist (210) 536–3605; DSN: 240–3605; FAX: (210) 536–6461
Environics Directorate	AL/EQ-CA 139 Barnes Drive, Suite 2 Tyndall AFB, FL 32403-5323	Katona, Michael, Dr., Chief Scientist (904) 283–6274; DSN: 523–6272; FAX: (904) 283–6064
Occupational and Environmental Health Directorate	AL/OE-CA 2402 E Drive Brooks AFB, TX 78235–5114	Farrer, Donald N., Dr., Chief Scientist (210) 536–2001; DSN: 240–6043; FAX: (210) 536–2025
Phillips Laboratory	PL/CA 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117–5776	Vacant, Chief Scientist (505) 846–0861; DSN: 246–0861; FAX: (505) 846–5128
Advanced Weapons Survivability Directorate	PL/WS 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117–5776	Baker, William L., Dr., Senior Scientist (505) 846–4040; DSN: 246–4040; FAX: (505) 846–0417

(DSN numbers are available only on Department of Defense telephones.)
Because of the recent restructuring of the Air Force laboratories, this preliminary list is subject to change.
See Alphabetical Directory for E-mail addresses for AFOSR personnel only.

Geophysics Directorate	PL/CAG 29 Randolph Road, Room 210 Hanscom AFB, MA 01731–3010	Hendl, Richard G., Dr., Chief Scientist (617) 377–3604; DSN: 478–3604; FAX: (617) 377–5688
Lasers and Imaging Directorate	PL/LI 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117–5776	Hogge, Charles B., Dr., Chief Scientist (505) 846–4735; DSN: 246–4735; FAX: (505) 846–0873
Propulsion Directorate	OL-AC PL/RK 5 Pollux Drive Edwards AFB, CA 93524–7048	Corley, Robert C., Dr., Chief Scientist (805) 275–5620; DSN: 525–5622; FAX: (805) 275–5086
Space and Missile Technology Directorate	PL/VT 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117–5776	Wick, Ray, Dr., Chief Scientist (505) 846–2603; DSN: 246–2603; FAX: (505) 846–2300
Rome Laboratory	RL/CA 26 Electronic Parkway Rome, NY 13441–4514	Vacant, Chief Scientist (315) 330–4512; DSN: 587–4512; FAX: (315) 330–4037
Command, Control, and Communications Directorate	RL/C3 525 Brooks Road Rome, NY 13441–4505	Graniero, John. A., Mr., Chief Scientist (315) 330–4114; DSN: 587–4114; FAX: (315) 330–1894
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